THE DENTAL PRACTITIONER

AND DENTAL RECORD

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THE DENTAL PRACTITIONER
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Vol. VIII, No. 8 April, 1958

EDITORIAL

CONSOLIDATION

It seems to have been an inordinately long winter this year, and we are still waiting for signs of spring. However, it will give a little more time to secretaries of societies to make up their winter reports on the activities of members before the calls of golf and the garden become too strong. The weather has probably meant a lower attendance at some meetings, but from the amount of material we have had submitted during the past months, we may presume that the winter's wind has blown in the right direction. The pen has prevailed over the inclemency of dark nights and wet week-ends. The words of the more fortunate ones will see the light of day and some will even be repeated as authoritative material. Others less fortunate will receive an ominous note saying that the editor, like Miss Otis, "regrets". While the winter months are the time for the small individual meeting, the summer months bring the larger and more exotic annual meetings, both in this country and on the Continent. After ten years of high activity in the professions, we must now enter a period of consolidation. Everything has been discussed so fully that one begins to wonder what the next step will be. After the war, the advance of cold-curing acrylics and chrome-cobalt castings were our main topic of conversation. This went on to a consideration of new local anæsthetics, air-abrasive, ultrasonics, and finally our latest talking point, the air-turbine handpieces and high-speed techniques.

Progress always seems to have periods of high activity, and we now enter a period when we must sit back and place these many advances in their correct perspective. Where history will place all of them is unknown, as already some of them have been relegated to the cellar. It is not always easy to make up our minds on the necessity of new equipment in practice and the tendency is always to wait and see. This will depend on the final clinical trials of any new method, but even then it does not by any means forecast its use by everyone. Economics have to be taken into account as well as usefulness. The dental profession has always been conservative by nature, but rapid changes are not always a sign of health. The policy of wait and see is invariably correct, provided that the new ideas are not lost sight of through prolonged procrastination.

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TISSUE REACTION TO SELF-CURING ACRYLIC RESIN IMPLANTS*

By **JENS WAERHAUG**, D.D.S., Ph.D.
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ACCORDING to earlier experimental investigations heat-curing acrylic resins are inert in relation to bone, connective tissue, and epithelium (Waerhaug, 1953, 1957; Waerhaug and Zander, 1956). For a review of the literature the reader is referred to an earlier publication on this subject (Waerhaug and Zander, 1956).

On the basis of experimental investigations on direct filling resins in human beings Nygaard Östby (1955) concluded that pathologic changes in the pulp are caused by these materials.

Similar conclusions were drawn by Langeland (1955) in a study on pulp reactions to resin cements and self-curing resin fillings lined with zinc-phosphate cement. Hedegård (1955) and Waerhaug and Zander (1957) observed that self-curing acrylic fillings revealed considerable marginal inaccuracy. Hegedüs and Inke (1957) applied cold-curing resin in empty tooth-sockets and allowed it to be polymerized there. On the basis of clinical and histological observations they maintained that the healing took place without inflammatory symptoms. Similar conclusions were drawn by Hoppe (1956). Hattemer (1956) injected quick-setting acrylic resin intramuscularly, intraperitoneally, and subcutaneously in rats, and inferred that the material is cancerogeneous.

As may be seen from the review of the literature, self-curing acrylic resins are usually considered to exert some irritation when used

Table I.—SOME OF THE MAIN DATA CONCERNING THE MATERIAL AND THE RESULTS IN THIS SERIES

DOG	TOOTH	OBSERVATION PERIOD	MAXIMUM DISTANCE ALVEOLAR CREST–GINGIVAL MARGIN	DISTANCE ALVEOLAR BONE IMPLANT	MAXIMUM DOWNGROWTH OF EPITHELIUM FROM GINGIVAL MARGIN	PRESENCE (+) OR ABSENCE (−) EPITHELIAL LINING WITHOUT CONNEXION WITH MARGINAL EPITHELIUM
		days	mm.	mm.	mm.	
19	$\overline{\|11}$	10	1·9	0 –0·25	1·3	−
20	$\underline{2\|}$	22	4·0	0·5 –1·2	2·1	−
24	$\underline{\|11}$	23	3·0	0·25–0·6	3·0	−
24	$\overline{11\|}$	23	2·2	0·1 –0·4	1·7	−
19	$\overline{\|5}$	30	1·8	0·3 –1·0	2·4	−
22	$\overline{\|3}$	30	3·7	0·2 –0·6	2·2	+
20	$\underline{\|2}$	30	4·0	0·75–1·8	3·9	−
22	$\overline{\|11}$	30	3·6	0·3 –0·8	1·9	−
22	$\overline{11\|}$	30	3·0	0·25–1·25	1·9	+
19	$\overline{\|5}$	30	2·6	0·4 –1·0	2·0	−
24	$\underline{\|2}$	33	1·3	0·4 –0·8	1·7	−
24	$\underline{2\|}$	33	3·9	0·1 –0·7	1·9	−
19	$\overline{5\|}$	38	3·0	0·25–0·5	1·0	−
24	$\overline{\|2}$	42	4·2	0·1 –0·5	2·3	−
21	$\overline{\|2}$	47	5·0	0·2 –0·8	4·3	+
22	$\underline{3\|}$	56	3·0	0·3 –1·1	1·9	−
19	$\underline{2\|}$	65	2·6	0·1 –1·2	1·6	+
24	$\overline{3\|}$	85	2·3	0·3 –1·0	4·0	−

* From the Norwegian Institute of Dental Research, Josefinegaten 32, Oslo, Norway.

as filling materials. The object of the present investigation is to find out whether or not self-curing acrylic resin is more irritating than heat-curing resins when used as implants in tooth-sockets. An answer to this question may throw some light upon the way in which self-curing acrylic resins act as an irritant when used as filling material.

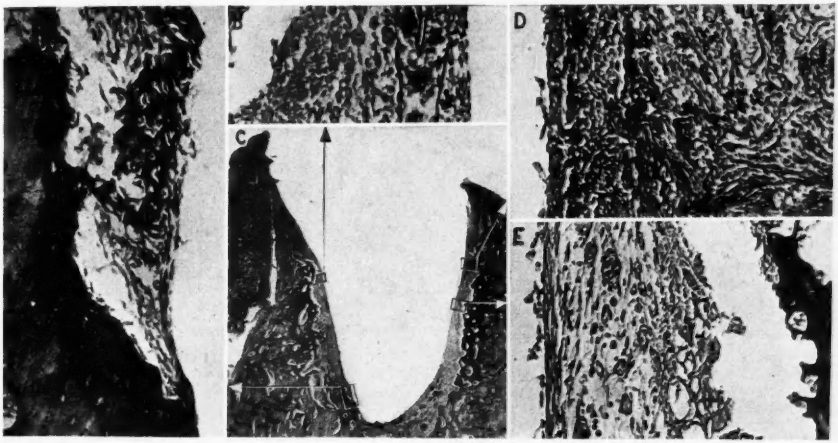

Fig. 1.—Dog 19. $\overline{11}$. Observation period ten days. Granulation tissue and young connective tissue between implant and bone. Formation of new bone (A) and organization of new vessels (B) directly upon implant. Slight downgrowth of epithelium from epithelial cuff (D). Area of resorption (E). (Azan.)

MATERIAL AND METHOD

Nineteen teeth in five dogs were used for the experiment. Under nembutal anæsthesia the teeth were extracted, and with these as patterns artificial roots were made out of self-curing filling resin* which had been allowed to polymerize shortly before. All the acrylic roots were finished with fine grit sand-paper disks, but none of them was highly polished. During the grinding some air-bubbles were opened up and appeared as pits in the surface. The implants were inserted within an hour after extraction; they extended 1–2 mm. above the gingival margin, and were retained in the socket by means of ligatures fixed to the neighbouring teeth.

After observation periods of from ten to eighty-five days, the animals were sacrificed. The jaws were taken out carefully and immersed in 10 per cent formalin. Before decalcification the acrylic implants were dissolved in chloroform according to a method previously described (Waerhaug, 1953). The specimens were embedded in paraffin and the sections were stained, some in hæmatoxylin and eosin, and some in azan.

* S. S. White, Texton.

OBSERVATIONS

Clinically, the healing was good. Eighteen of the artificial roots remained in place during the entire observation period; one implant had to be removed on account of extensive suppuration from the socket.

The histologic examination revealed that severe inflammation did not occur. The remnants of the periodontal membrane disappeared within ten days (*Fig.* 1) and granulation tissue, connective tissue, and epithelium occupied the space between the bony socket and the implant (*Figs.* 1–10). Extensive bone resorption had ceased, but minute resorption areas were observed in all stages of healing (*Figs.* 1 E, 5 D, 6 C). Apposition of new bone was common (*Figs.* 2, 3, and 8), and could be seen already after ten days; in one place it was even found in contact with the implant (*Fig.* 1 A). The distance from the alveolar crest to

the gingival margin ranged between 1·3 and 5·0 mm. (*Table I*). Inflammatory cells were seen in limited areas of the connective tissue, the inflammatory reaction was slight or absent (*Figs.* 2, 3, 8, and 9), and the collagen fibres were orientated parallel to the artificial roots

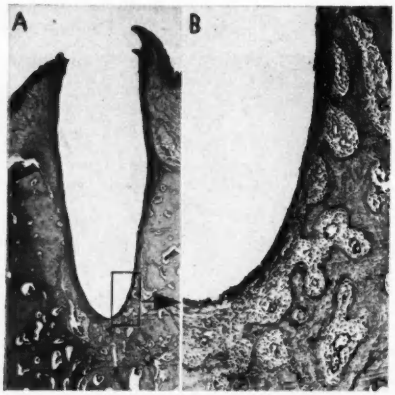

Fig. 2.—Dog 24. $\overline{11|}$. Observation period twenty-three days. New alveolus formed around implant (A). Between implant and bone, young connective tissue. (H. and E.)

Fig. 3.—Dog 22. $\overline{11|}$. Observation period thirty days. Advanced formation of new alveolus. Normal connective tissue with fibres orientated parallel to surface of implant. Epithelium covers the marginal two-thirds of socket. (H. and E.)

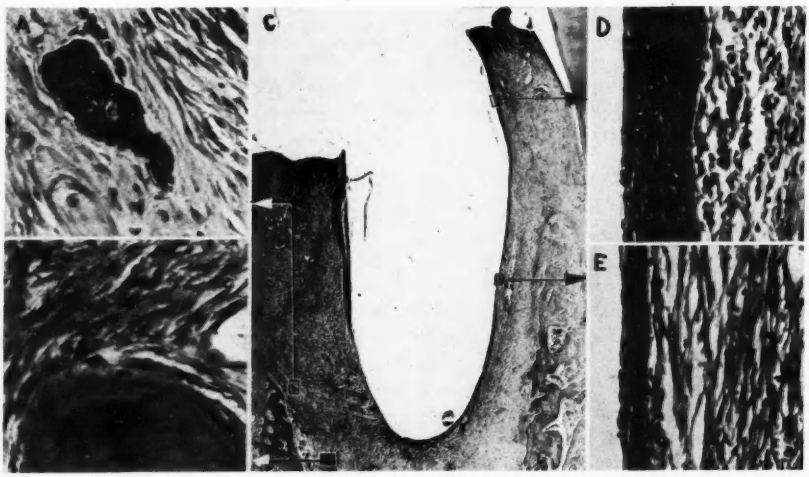

Fig. 4.—Dog 20. $\underline{|2}$. Observation period thirty days. Tooth fractured during extraction. Formation of bone upon root fragment (B). Proliferation of epithelial rests of Malassez (A). Polymorphonuclear leucocytes between the cells of the epithelial cuff (D, E).

especially in the marginal half of the socket (*Figs.* 1, 5, 7, and 8). However, no necrosis could be observed, and new blood-vessels were formed almost in contact with the implant *Fig.* 1 B). In the apical half of the socket (*Figs.* 2–4 and 6–9). In most cases the superficial connective tissue bordering upon the implants was condensed to form a cuticle-like membrane (*Figs.* 2, 3, 5 A, 6 B, C, 8 C, and 9 C). Downgrowth of epithelium took place

in most cases, although the speed was variable (*Table I*). In a few cases the apical part of the implant was lined with epithelium which seemingly had no connexion with that

DISCUSSION

According to this series there seems to be no basic difference in the tissue reaction to self-curing acrylic implants as compared with

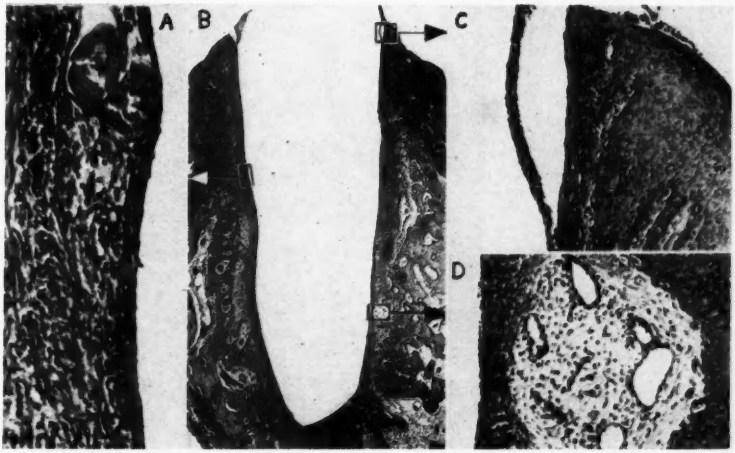

Fig. 5.—Dog 24. $\frac{2}{1}$. Observation period thirty-three days. Non-inflamed connective tissue adhering to implant. Hairs from the dog in connective tissue and accumulation of inflammatory cells correspondingly (A). No downgrowth of epithelium from gingival margin (C).

proliferating from the gingival margin (*Figs.* 3 and 7). Occasionally, subgingival plaque was formed on the implant (*Fig.* 6 A), and in the adjacent tissue inflammatory cells were seen. But even in cases without deposition of plaque, polymorphonuclear leucocytes were observed within the epithelium or between this and the implant (*Figs.* 4, 7, and 9). However, adaptation of approximately normal epithelial cells to a cuticle-like membrane on the surface of the implant was also seen. These epithelial cuffs (*Figs.* 7 D and 7 E) did not differ mentionably from the "epithelial attachments" on control teeth (*Fig.* 7 D).

During the extraction two teeth fractured. No attempt was made to remove the roots, and the implants were inserted as usual. The condition of the tissue around these implants did not differ from the others. (*Figs.* 4 and 8.) Formation of bone took place upon the root-fragments (*Fig.* 4), and no inflammatory reaction could be observed in the deeper part (*Fig.* 8). Enlarged epithelial rests of Malassez could be seen in the neighbourhood of the root-fragment (*Fig.* 4 A).

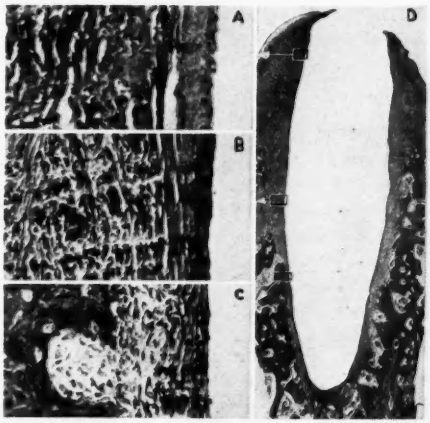

Fig. 6.—Dog 24. $\frac{2}{1}$. Observation period forty-two days. Deposition of bacterial plaque upon implant (A), with cellular infiltration in adjacent tissue. Absence of inflammation in connective tissue (B). Minute resorption area in the apical third (C). (Azan.)

heat-cured ones (Waerhaug, 1953, 1957; Waerhaug and Zander, 1956). Some cellular infiltration was regularly seen close to the

gingival margin, but this was hardly more than found around the neighbouring teeth. This inflammation was obviously caused by the the socket. From the gingival margin the inflammatory response decreased apically and could in many places be completely lacking.

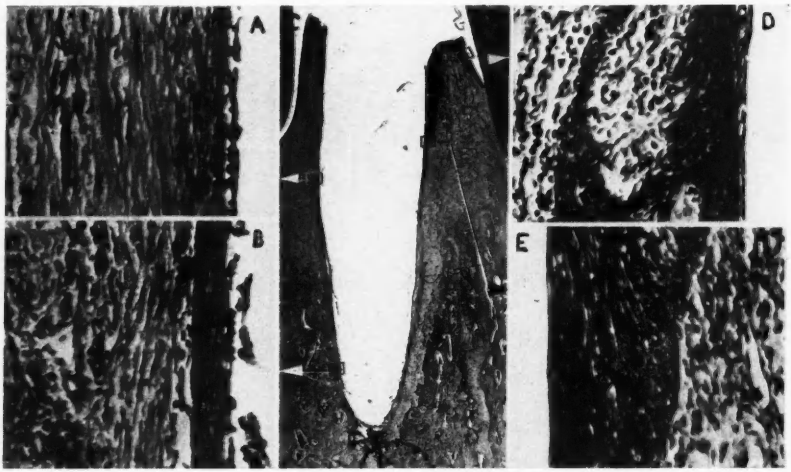

Fig. 7.—Dog 21. $\overline{2}|$. Observation period forty-seven days. Epithelial cover in apical part without connexion with marginal epithelium (A, B). Slightly thickened epithelial cuff with cuticle bordering upon implant (E). For comparison is shown epithethelial cuff on enamel on adjacent tooth (D). (H. and E.)

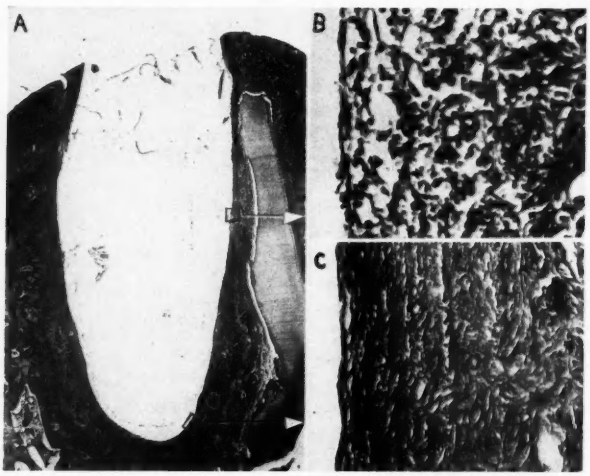

Fig. 8.—Dog 22. $\underline{3}|$. Observation period fifty-six days. Tooth fractured during extraction. New alveolus formed around implant. Implant surrounded apically by normal connective tissue (C). Granulation tissue in the marginal half (A). (Azan.)

food particle and bacterial plaque which was easily retained on the implant because of the ligatures used for retention of the implant in Normal connective tissue was found in contact with the resin implants in such places, indicating that they did not act as irritants. Limited

local areas of inflammation were seen, but these could easily be explained as being caused by impacted hairs (*Fig.* 5) or necrotic bone fragments (*Fig.* 10). The uneven surface, caused by the opening up of the air-bubbles, did not seem to exert serious irritation although some degree of degeneration and in many cases polymorphonuclear leucocytes were found between the implant and the epithelium. This was most likely caused by some seepage of tissue-fluid mixed with leucocytes along the implant. The finding of an epithelial lining in

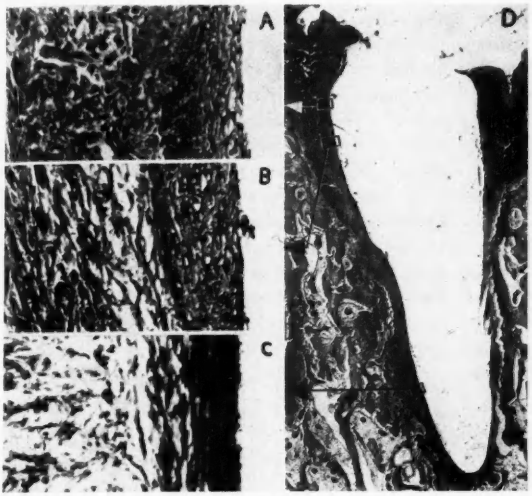

Fig. 9.—Cells in epithelial cuff are somewhat degenerated, but adheres directly to cuticle-like membrane on implant (A, B). Connective tissue fibres arranged parallel to surface of implant (C).

Fig. 10.—Piece of necrotic bone between epithelium and implant.

it cannot be excluded that some of the inflammatory foci were originated in this way. This is in accordance with earlier findings that a rough surface in itself is not irritating to soft tissue. It is to be presumed that the healing took place much in the same way as around heat-cured resin implants, although some more inflammation may have been caused by free monomer. However, this extra irritation, if any, obviously ceased within ten days and the final healing was not jeopardized.

Even the epithelium adhered in some cases to the cuticle-like membrane on the surface of the implant (*Fig.* 7). The acrylic-epithelial junction was in that case very much like the enamel-epithelial junction of the epithelial cuff around control teeth (*Fig.* 7), thus demonstrating the inherent tendency of the epithelium to seal any break in its continuity. However, these epithelial cuffs always exhibited the deeper part of the alveolus without connexion with the marginal epithelium is strong evidence that the epithelial rests of the periodontal membrane (*Fig.* 7) are able to proliferate and in this way contribute to the epithelial enclosure of the implant. Thus, the haphazard proliferation of the epithelial rests may account for the great variation in the width of the epithelial cuffs, the width being unrelated to the length of the observation period (*Table I*).

The findings made here, that self-curing acrylic resin implants do not exert appreciable irritation to the soft tissue ten days or more after polymerization, are in accordance with the conclusions drawn by other authors (Hegedüs and Inke, 1957; Hoppe, 1956). On the other hand, it has been shown that self-curing resin used as filling material is irritating to the pulp (Langeland, 1955; Nygaard Östby,

1955) and even to the gingivæ (Waerhaug and Zander, 1957). This discrepancy may easily be explained by the different conditions under which the material is used in the different studies. If the rest of unpolymerized monomer causes the pulp reaction, this rest monomer will after some time have no influence around the implants as it will be removed with the tissue fluid. Neither will heat generated during the polymerization, nor poor marginal seal, have any influence. Therefore, no definite conclusions can be drawn as to what causes the pulp reaction. It can only be suggested that the main damage may be caused during, and shortly after, the polymerization by free monomer. But it must also be expected that some free monomer may be retained between the filling and the cavity wall (Axelson, 1955). The rather extensive inflammation in the gingiva adjacent to self-curing resin fillings (Waerhaug and Zander, 1957) is most likely the consequence of poor marginal seal rather than irritation from the material itself.

SUMMARY AND CONCLUSIONS

Nineteen teeth in five dogs were extracted and replaced by implants made of self-curing acrylic filling resin which was allowed to polymerize shortly before insertion. After observation periods of from ten to eighty-five days, the animals were sacrificed. On the basis of histologic examination the following conclusions may be drawn:—

1. Auto-polymerized acrylic resin used as implants exerts little, if any, irritation to periodontal tissue 10 days, or more, after insertion. In this respect cold-curing resins do not seem to differ from heat-curing ones.

2. Connective tissue with the fibres orientated parallel to the surface embraces the implant until the epithelium grows in between.

3. New bone is formed rather close to the implants.

4. Epithelial cells of approximately normal appearance may adapt themselves to the implant and proliferate apically.

5. Epithelial rests of Malassez left behind during the extraction may proliferate and contribute to a more rapid epithelization.

6. The pathologic conditions in the pulp beneath direct filling resins are probably due to the damage caused before the polymerization is concluded and, possibly also, to the leakage at the margins of the fillings.

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Tissue Reaction to Metal Wires in Healthy Gingival Pockets

Ligatures of stainless steel, iron, and brass were placed in healthy gingival pockets around 21 teeth in 4 dogs and 2 teeth in a monkey. Surgical examination after intervals varying from 7 to 206 days show that the wires were well tolerated, stainless steel being apparently the least irritating.

In some cases the wires were within the pocket and in others embedded in the corium of the gingival tissue. In both they were completely surrounded by epithelium. The epithelial cuff showed, in most cases, normal relation to the tooth surface.

In a few cases the wires appear to facilitate retention of a bacterial plaque and a slight deepening of the pocket was also observed occasionally.

In 5 teeth where the ligature had been removed sometime before termination of the experiment, complete healing was observed in all except 1 case where a subgingival plaque persisted.—Waerhaug, J. (1957), *J. Periodont.*, **28**, 239.

SECTIONAL ROOT FILLING WITH SILVER POINTS

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It is now widely recognized that the complete obliteration of a root-canal by filling constitutes a most important part of the therapeutic technique. Dow and Ingle (1955) state that in a two-year study of 532 completed cases, 18 of the 34 failures were due to incomplete obliteration of the root-canal. On the other hand, Strindberg (1956) demonstrated in a recent study that pronounced overfilling resulted in a significantly lower success rate than where there was only slight or no overfilling.

With an anterior tooth, the difficulty of producing a thoroughly condensed root filling is largely due to two factors—the anatomy of the root-canal, the side walls of which converge in varying degree from the coronal to the apical end, and the tendency of the canal to be ovoid in section coronally. Although the use of reamers and files of a diameter greater than the apical portion of the canal must result in the latter becoming circular in section, the somewhat greater width coronally precludes this, especially with the wide canals of young teeth. It follows that the use of points matching in size the hand instruments used, although perhaps fitting satisfactorily at the apex, will—for most of their length—be out of contact with the side walls of the canal. Therefore, if a root-canal point combined with cement is relied upon with no additional means of compression, a poorly condensed root filling is likely to result (*Fig.* 1).

To obviate this difficulty, gutta-percha points may be used by either a lateral condensation or a sectional technique. In the former, a single point coated with cementing medium is fitted to the apex of the canal and additional cones inserted and compressed alongside it. In the latter technique, as described by Coolidge and Kesel (1956), the apical end of the appropriate sized point is secured to the end of a warmed root-canal plugger and seated in position apically. Additional sections of gutta-percha are then inserted and packed into the canal. To facilitate spreading of the gutta-percha, the canal is moistened with chloroform or eucalyptus. Due to the compressible nature of the material used, both methods suffer from the disadvantage that it is all too easy, even in expert hands, to thrust gutta-percha and/or cement into the periapical tissues. This disadvantage may be overcome

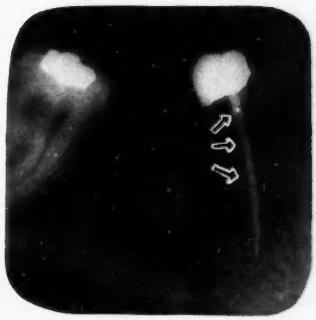

Fig. 1.—The root-canal of $\overline{4}|$ was filled with one gutta-percha point and cement. The area of under-condensation is arrowed.

by the use of silver points and cement, as advocated by Jasper (1941). Since the material used is incompressible, there is no danger of overfilling if cement is not carried beyond the apex when the point is first seated, and so long as the latter is not dislodged in an apical direction. Sections of gutta-percha are packed alongside the silver point to provide lateral condensation. This technique undoubtedly results in technically excellent fillings. If later post-crown construction is necessary, however, drilling away sufficient silver point in order to accommodate the post may well present much difficulty, with the possibility of root perforation.

It would seem that in order to retain the advantages inherent in the use of a silver point, and yet avoid the difficulty which sometimes arises later during post-crown construction, it would be better to obliterate first the

apical part of the canal with a section of silver point, and then to fill the remainder with a material which, if necessary, may be removed later with ease. Owing to the difficulty of fixing a section of silver point to a root-canal plugger, the following technique was devised.

TECHNIQUE

The success of any method of root filling obviously depends in part upon the accuracy of the mechanical preparation of the canal which has preceded it. If mechanical preparation has stopped short of the apex, then a root filling with a matching point must also be short. As will be shown later, however, the converse need not apply. It is still possible, although technically far more difficult, to fill satisfactorily a canal which has been reamed or filed beyond its apex. (*See Fig.* 6.)

Assuming that preparation of the canal has been accurately performed, a silver point corresponding in size to the largest file which will reach the apex is selected. The tip of the point is trimmed with sandpaper disks to correspond to the end of the file (*Fig.* 2).

The point is sterilized by flaming and inserted into the canal. By direct measurement of the length of point protruding beyond the incisal or occlusal edge it is calculated whether the apex has been reached (measurement is facilitated if the butt-end of the point, which is usually rounded, is trimmed flat). Using a vulcarbo disk, a deep groove is now cut round the circumference of the point, at a suitable distance from its tip (usually 4–5 mm.) (*Fig.* 2). On the assumption that the length of the post of any subsequent post-crown should at least equal that of the crown, the actual position of the groove may be determined by doubling the

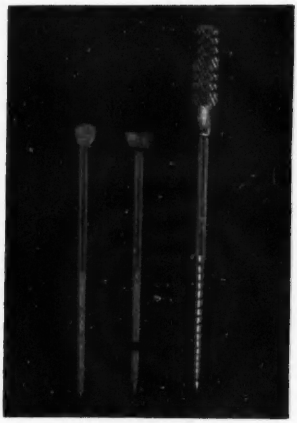

Fig. 2.—The point on the left is not trimmed. The tip of the right-hand point has been trimmed to correspond to the file, its butt-end flattened to facilitate measurement, and a deep groove cut a few millimetres from its end.

A B

Fig. 3.—Satisfactory healing of a chronic apical abscess associated with $\underline{1}|$. A, Dec. 1, 1955; B, Nov. 11, 1957.

length of the clinical crown and subtracting this from the total tooth length. The resultant length represents the maximum distance from the tip of the point to the position of the groove. The latter should be of sufficient depth for the two sections of the point to be easily separated by twisting.

An absorbent paper-point of suitable width is now inserted to the apex to keep the canal as dry as possible until the moment of filling,

Fig. 4.—The palatal root-canals of $\overline{|67}$ have been filled apically with sections of silver points.

Fig. 6.—Over-instrumentation of the root-canal of $\underline{|1}$ has necessitated trimming the end of the silver point.

when it is removed. The terminal portion of the silver point is lightly coated with a creamy mix of oxyphosphate cement. The tip of the point is touched gently on the mixing slab (to ensure that no cement protrudes beyond its end). The point is now inserted to the apex and checked for position. After allowing 2–3 minutes for the cement to set, the butt-end of the point is given 2 or 3 complete rotations with pliers or dissecting forceps and removed,

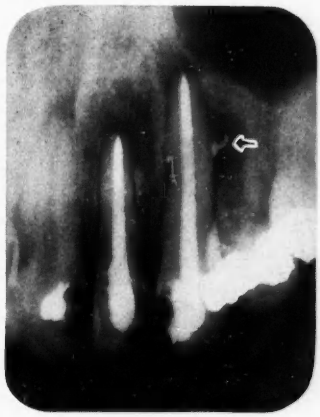

Fig. 5.—The presence of a lateral canal on the distal aspect of $\underline{|3}$ root, suspected because of the presence of a separate lesion distally, is demonstrated by the excess filling (arrowed).

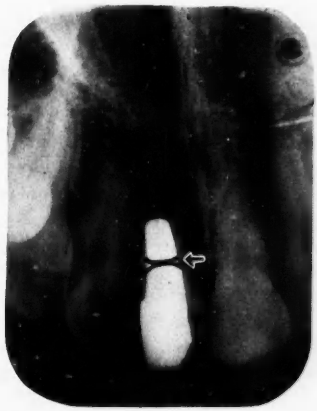

Fig. 7.—The open apex of $\underline{1|}$ has been filled with a cast silver post. The junction of the latter and the post-crown is outlined and arrowed.

leaving the apical part of the canal filled with silver. The remainder of the canal is now obliterated with a creamy mix of zinc oxide–eugenol and gutta-percha cones. As with all

methods of filling, the technique described presents possible limitations and disadvantages:

1. The possibility of disruption of the bonding cement when the butt-end of the point is rotated cannot be disregarded. In more than 150 cases treated over the past 18 months by this method, there has been no reason to suspect that this has occurred. Periapical healing has proceeded satisfactorily in the cases treated (*Fig.* 3).

Fig. 8.—A perforation of the root of $\overline{5}$ has been repaired by filling with a section of silver point. Note that this presented no obstruction to filling the main root-canal.

Important factors in avoiding this difficulty are adequate grooving of the point, and allowing sufficient time for the cement to set. The former is carried to the state where the grooved portion is *only just* strong enough to support the weight of the point beyond.

2. Points smaller than size No. 5 (Produits dentaires) cannot be grooved satisfactorily. In consequence, the technique is not always applicable to lower incisors, and cannot be used for posterior teeth (with the exception of lower premolars, single-rooted upper premolars, and the palatal roots of upper molars) (*Fig.* 4).

3. Removal later of the terminal portion of the point is not possible, except by a surgical approach. Therefore, if treatment fails, extraction or apicectomy (or curettage) is necessary. On further inspection it will be realized that this disadvantage is more apparent than real. A treatment that fails, assuming it to have been properly executed in the first instance, would normally be corrected surgically.

Apart from the ease of lateral condensation without fear of overfilling and the avoidance of difficulty in later post-crown preparation, the technique offers certain minor advantages:

1. If post-crown construction is necessary, this may be commenced immediately after cementation of the silver point. Any undercuts and excess cement still remaining in the unfilled part of the canal are removed with rosehead burs. It should be remembered, however, that lateral canals may communicate with the main canal coronal to the silver point (*Fig.* 5). To avoid the possibility of reintroducing infection into the periapical tissues via these canals, the main canal should be packed with cotton-wool moistened with Dettol whilst the crown is trimmed. Sterile burs should be used in preparing the canal, which should be isolated from saliva whilst impressions are taken. A saliva-tight seal is necessary between visits.

2. If instrumentation beyond the apex has occurred, the technique may be modified by trimming the end of the point to the necessary shape (*Fig.* 6). The use of a gutta-percha cone in such cases would be more likely to result in overfilling. Also, accurate trimming is far more difficult.

In selected cases, teeth with open apices may also be treated. If the diameter of the canal apically exceeds that of the largest point available, then the canal is cleansed with straight rosehead burs, and a silver post cast to match in width the largest bur used (*Fig.* 7).

3. Some root perforations may be treated by this method, the point being trimmed as necessary and grooved in such a position that it does not interfere with the filling of the main canal (*Fig.* 8).

SUMMARY

The disadvantages of routine methods of root filling are stated, and a technique of filling sectionally with silver points to overcome these disadvantages is described. The limitations and advantages of the method are discussed, and illustrated by treated cases.

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TREATMENT OF THE UNERUPTED MAXILLARY CANINE*

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THIS paper is intended to serve as a practical contribution to the diagnosis and treatment of misplaced maxillary canines. There are very few forms of canine impaction which will not respond to treatment with reasonable co-operation from the patient. It is hoped, however, that this may be seen in true perspective, as treatment for this condition is not always desirable nor necessary. Sometimes the buried tooth is better left where it is; sometimes it is better extracted, but where the patient will benefit from treatment designed to move this tooth into the arch no effort should be spared.

Provided that the canine has not impacted into the roots of the incisors, or cystic changes have not occurred around the tooth, very little harm results from leaving a canine buried in the palate. There is very little evidence that once the late teens have been reached there is any danger of resorption, death, or displacement occurring in the incisor teeth. The troubles in this respect usually arise in the younger patients, where they must be diagnosed and treated. In any case, periodic X-ray examination provides an adequate safeguard where a canine is known to be impacted but for some reason is not treated.

EARLY DIAGNOSIS

The treatment involved, in moving an impacted canine into place in the arch, is usually long and tedious and not without its particular difficulties. Prevention of this condition is obviously the ideal form of treatment. It should be common practice among all dental surgeons to palpate and register the position of the upper canines soon after the incisors have erupted into the arch. There should be a greater consciousness of canines at this stage in the development of the dentition. Provided that a slight bulge can be palpated high up in the buccal sulcus in good relationship with the adjacent teeth, the canine is likely to erupt into normal position, the exception being where a considerable displacement of the upper lateral incisor has occurred. Where this condition is present or the canine bulge cannot be identified, it is expedient to investigate the position of the tooth with X rays. Root resorption of an incisor tooth is usually initiated during the early eruption stage, particularly when the canine crown moves into the immediate vicinity of an incompletely formed apex of an incisor tooth. Marked displacement of a lateral incisor due to pressure from an erupting canine may be the first indication of this danger. Where it is not possible to discern the canine bulge by digital palpation, a simple intra-oral X ray may show whether the cause is quite innocent. On the other hand, much time and orthodontic treatment may be avoided by the early diagnosis of a canine which is being displaced into the palate.

PREDISPOSING CAUSES

The eruptive course of the canine is a long one, and because of this the tooth is more exposed to unfavourable influences during its eruption. Impaction occurs more commonly under certain conditions.

1. General Causes.—

a. Narrow upper arches which are deficient laterally in the inter-canine width.

b. Dental arches with a tendency towards deep incisor overlap and some retro-clination of the incisors. Where there is a reduction of canine space in the anteroposterior dimension.

c. Mouths which have suffered early loss of deciduous teeth, resulting in a reduction of premolar and canine space.

2. Local Causes.—

a. The presence of a non-vital deciduous canine tooth must be viewed with great

* A paper read at the meeting of the British Society for the Study of Orthodontics held on Dec. 9, 1957.

suspicion. A granuloma is capable of deflecting an erupting canine into the palate although there may be sufficient space for it in the arch.

b. Dentigerous cyst. It is probably no coincidence that misplaced canines are often surrounded by an enlarged tooth-follicle. The canine requires the presence of the adjacent teeth to guide it in its eruptive course. The cushioning effect of an enlarged tooth-follicle, and even more so with a dentigerous cyst, removes the influence of the adjacent teeth so that the canine is readily diverted from its proper course into the palate or the buccal side of the arch.

c. Congenital absence of 2|2. The absence of two teeth from the anterior part of the arch would be expected to simplify the natural eruption of the canine. In fact, the absence of the guiding influence of the upper second incisor permits a forward movement of the canine mesially to the roots of C|C. The roots of these teeth then provide an excellent incline plane, down which the permanent canine slides until it moves into contact with the upper central incisor or is deflected into the palate.

d. Resorption of the temporary canine. Tardy resorption or lack of uniformity in the resorption of the root of the temporary canine may either prevent the normal eruption of or displace the permanent canine from the arch.

APPRAISAL OF THE POSITION OF AN UNERUPTED CANINE

The crux of the whole approach to this problem lies in a thorough examination of the patient. Before attempting treatment it is essential to gain a very accurate mental picture of the position and angle at which the canine is lying. There are many variations of the position in which the crown of the canine may be lying. It may be:—

1. Lying palatal to the arch.
2. Lying buccal to the root of the lateral incisor.
3. Impacted distally against the root of the lateral incisor.
4. Impacted vertically above the apices of the incisors.

The surgical interference required to reach and expose the buried tooth may be extensive and the region of approach will obviously be varied to meet the requirements of a particular case. This makes the pre-operative examination all the more important. Bearing in mind the above positions of the tooth, the following order of examination is usually employed:—

1. Digital palpation.
2. Visual examination.
3. Vitality tests of the teeth in that region.
4. X-ray examination.

The information obtained from a single form of examination is not taken entirely on its own merits but is correlated with or weighed against data gained from the other forms of investigation.

1. Digital Palpation.—

a. The Crown of Canine.—A firm bulge which can be palpated on the palatal side of the arch invariably indicates that the crown of the canine is lying in the palate and is not very deeply placed. Sometimes, however, the lateral incisor may have its root displaced palatally by the pressure of a canine lying on its buccal aspect. This situation also produces a bulge on the palatal side of the incisor. A tooth which is lying in a very deep position in the palate may not produce a palpable bulge.

The crown of a tooth which is lying on the buccal side of the roots of the upper incisors will invariably produce a bulge in the buccal sulcus.

In those cases where the misplaced tooth is lying in the alveolus distal to the root of the lateral incisor, vertically impacted above the incisors, or where there is congenital absence of the lateral incisor, it may not be possible to detect the position of the crown of the canine by palpation. The degree of looseness or firmness of the deciduous canine and the permanent incisors in the region of the buried tooth may be tested. Valuable information may thus be gained as to the proximity of the permanent canine to these teeth. Some indication is given of the degree of resorption in the deciduous canine and the possibility of resorption having occurred in the roots of the incisors.

b. The Position of Apex of Canine.—Where orthodontic treatment is to be attempted to move the misplaced canine into the arch, the limiting factor will often prove to be the position of the apex of the tooth. Fortunately the apex is commonly found to be lying above and buccal to the root of the first upper premolar. A fully developed canine in which the crown has been displaced into the palate shows a corresponding outward displacement of its apex. This may be palpated in the buccal sulcus above the apex of the first premolar.

2. Visual Examination.—

a. The Crown of Canine.—Working on the assumption that two bodies cannot occupy the same space, it is possible to determine the position of the misplaced canine by examining the axial inclination of the incisors. The crown of a misplaced canine which is deeply placed and lying on the palatal side of one or more incisors will cause an outward displacement of their roots. It is more common to find the root of the second upper incisor displaced in this manner. The effect of this movement will be to tilt the crown of this tooth inwards towards the palate, the exception being where the canine is lying just under the surface on the palatal side and pressing forwards on the coronal aspect of the incisor and tilting it forwards.

The pressure of the crown of the canine impacted against the distal aspect of the root of the second incisor will have the effect of displacing the root of this tooth mesially against the central incisor. The crown of the lateral incisor will be tilted distally, giving a clear picture of the position of the crown of the impacted tooth.

Pressure from the crown of a canine, lying on the buccal aspect of the root of the lateral incisor, will cause an inward displacement of its apex. This movement will show a corresponding outward deflection of the crown of the lateral incisor.

b. The Apex of Canine.—The presence of a misplaced or impacted tooth in the canine region will invariably provide topographical clues as to the position of its root. In addition to the displacement of the incisors by the crown of the canine, some changes may be detected in the alinement of the premolars. The presence of the root of the canine on the buccal side of the premolar usually results in the inward displacement of the apices of this tooth. This causes the crown of the premolar to be displaced buccally. Where the root of the canine is lying on the palatal side of the premolar the reverse effect may be seen or the premolar may even be rotated by this pressure.

3. Vitality Tests.—Heat, cold, and electric pulp tests may be made to determine the vitality of the incisors in the vicinity of a buried canine. Death of the pulp of an incisor sometimes occurs with or without root resorption of an incisor having occurred. This would be likely to influence the course of treatment and is better detected sooner than later. Root resorption of an incisor does not usually destroy the vitality of the tooth. Electric pulp tests show, however, that the pain threshold of the pulp may be lowered.

4. X-ray Examination.—The examination up to this stage will probably provide most of the information required to determine the approximate position of the canine, the exception being those patients with congenital absence of the lateral incisors. In the main, radiographs are used to confirm the findings of the clinical examination.

An intra-oral X-ray of the canine region gives valuable information of the proximity of the crown of the buried tooth to the roots of the incisors; the amount of bone overlying the buried tooth; the congenital absence of a lateral incisor; possible root resorption of the incisors; the presence of a granuloma at the apex of the deciduous canine; the presence of a dentigerous cyst in relation to the permanent canine; the deviation of the permanent canine from its vertical axis and the position of its apex. Where the tooth is lying in a grossly misplaced position, a second intra-oral view of the apical region is advisable from a different angle. Comparison of the two views will be of great value in assessing the position of the apex.

Stereoscopic occlusal radiographs are used to supplement the intra-oral view. Using the

principle of parallax, the precise relationship of the crown of the canine to the roots of the incisors may be determined. Where there is any previous doubt as to whether the misplaced tooth is lying on the buccal or palatal side of the arch, these radiographic views will provide that information. Further confirmation of the position may be made from a vertex-occlusal view of the arch. This is taken with the X rays passing through the vertex of the skull down the long axis of the incisors. This view is also of value in assessing the position of the apex of the canine.

Teeth which are very deeply placed and vertically impacted above the roots of the incisors require a lateral radiographic view. This is of value in assessing the position of the buried tooth in the anteroposterior plane, so that the most convenient path of surgical access may be determined. Such teeth commonly show a slight tendency to be buccally placed.

INDICATIONS FOR ORTHODONTIC TREATMENT

There are many factors to be considered before deciding upon the course of treatment. Very rarely are all the indications favourable, but certain criteria must be fulfilled before a patient can be advised to undertake orthodontic treatment.

1. Value of the Canine to the Dental Arch.—This would appear to be a fundamental consideration, but it is very easy to consider the problem merely as one of a misplaced canine to be brought into place and not one of restoring the whole arch to the best advantage. Mr. Walpole Day (1955) suggested that atrophy of the pulp sometimes occurs in an impacted canine. It has also been asserted that the pinning of a buried canine is likely to be followed by death of the pulp of the tooth (Fastlicht, 1954). The first observation has not been confirmed in a limited number of cases investigated, and the second observation has not been borne out in any case treated.

The canine is generally considered to be the strongest rooted tooth in the arch and to be very pleasing æsthetically. As such, the tooth is well worth conserving. At times, however, when a considerable degree of canine space has been lost, the first upper premolar makes an excellent substitute for the canine. Where the canine is in a very poor position and a good orthodontic result can be achieved without retaining it, the canine is better extracted.

2. Co-operation of the Patient.—A keen, co-operative patient is a great asset in any form of orthodontic treatment, but in the treatment of an impacted canine it is a necessity. Patients who habitually break appliances and those who are unlikely to co-operate fully with appliances are considered a poor risk. A tooth with a pin in it has to be treated very carefully as constant rough usage may break or dislodge the appliance. It is not always possible to recognize a patient likely to break appliances, but it is a good rule to insist that the patient is extremely keen to undertake the treatment required. In the older patient this is found to be more important than the parents' desire for treatment. A great cause of concern among teenage patients is whether the appliance is likely to cover the front teeth and be disfiguring as a result.

3. Age of Patient.—The majority of the patients referred for treatment are between 12 and 15 years of age. The condition is already well established at this age, but the teeth usually respond to orthodontic treatment. Canines are difficult teeth to move, so that the older patients invariably require the extraction of a premolar to facilitate treatment. The ideal age-group for treatment is between 9 and 12 years of age before the condition is well established.

4. Space Available.—The ultimate problem becomes one of providing sufficient space to accommodate the permanent canine. The deciduous canine is usually in position but space is invariably lost by the forward drift of the buccal segments. The younger the patient the better the prospect of providing room for the unerupted tooth within the arch. Where space has been lost in the older patient extraction of a premolar is usually required. Often a close relationship is present between the roots of the canine and first premolar, so

that the choice of extraction is usually the first premolar. Sometimes it is difficult to justify the extraction of a premolar which is in good position in order to provide space for a buried canine which is in a poor position.

5. Difficulty of Treatment.—

a. Surgical Procedure.—It was said earlier that there are very few forms of canine impaction which will not respond to treatment provided that there is reasonable co-operation from the patient. Other factors are also of importance, such as the depth of the buried tooth and the position of its apex, also the degree of impaction as well as the age of the patient and the space available. Although the surgical technique is not particularly difficult after a few salient points have been mastered, it is not a method to be undertaken lightly. Many difficulties can arise, such as damage to the adjacent teeth and to the canine. The less favourable the position of the buried tooth the more these risks have to be considered.

b. Orthodontic Treatment.—It is fortunate that the apex of the canine is usually in a favourable position so that the orthodontic movement required is a tipping action. The crown undergoes most of the movement and little change occurs in the apical region (*Fig.* 1). Where the apex appears to be distally placed the orthodontic movement is still satisfactory as a rule. The spring-traction applied to the tooth will draw the tooth down in addition to the tipping action on the crown. This results in a form of follow-through movement in the apical region.

The farther forwards the apex is lying the more difficult does it become to move the canine into a pleasing position. In these cases there is a close relationship between the lateral incisor and the canine. Provided that the first premolar is a satisfactory tooth capable of being moved into good alinement, the emphasis of treatment is on extraction of the canine.

The depth of the buried tooth puts a proportionate limitation on the chances of success, as does the degree of impaction of the canine against the roots of the incisors. Pins are sometimes used to a great depth, and although they can be used successfully to reach down and bring about tooth movement, the other factors must be favourable. An extra strain by a heavy bite may be put on the pin which results in its displacement or fracture. The reduction of a severe impaction may increase the amount of movement required to such a degree as to render orthodontic treatment undesirable even if not impossible.

Fig. 1.—Radiographs of patient aged 15 years. To show movement of $\underline{|3}$ which has taken place with orthodontic treatment over five months. The movement of $\underline{|3}$ is primarily a tipping action of the tooth.

A deep incisor overlap is often associated with this condition, and where this is severe a further hazard has to be considered owing to the danger of displacement or breakage of the apparatus. Sometimes this difficulty can be overcome by introducing the pin into the tooth from an alveolar or a buccal approach.

6. Root Resorption of Incisors.—The mechanism which initiates root resorption of an incisor tooth due to the close relationship of a buried canine to it is not clear, but it occurs often enough to deserve consideration. The movement of an erupting canine across the

apical region of a lateral incisor may be sufficient to cause resorption of the incisor root, although the canine may continue its eruptive course into normal alinement (*Fig.* 2). It is more common for the erupting canine to impact itself into the apical region of an incompletely formed incisor to initiate the resorption process, although this sequel does not invariably follow the impaction.

Early diagnosis is essential as the progress of the resorption process may be rapid. The first indication of this occurrence may be the loosening of an incisor. At times resorption is so severe that the damaged tooth is better extracted to allow the canine to erupt into its place in the arch (*Fig.* 3).

Fig. 2.—Patient aged 12 years. Radiographs show extensive resorption of $\underline{2|2}$ which occurred during the unaided eruption of the canines. Both teeth are vital.

Fig. 3.—Radiographs and photograph of extracted $\underline{2|}$ showing extensive resorption of this tooth due to the presence of an impacted canine. $\underline{2|}$ was extremely loose and extracted so that $\underline{3|}$ could be brought into position.

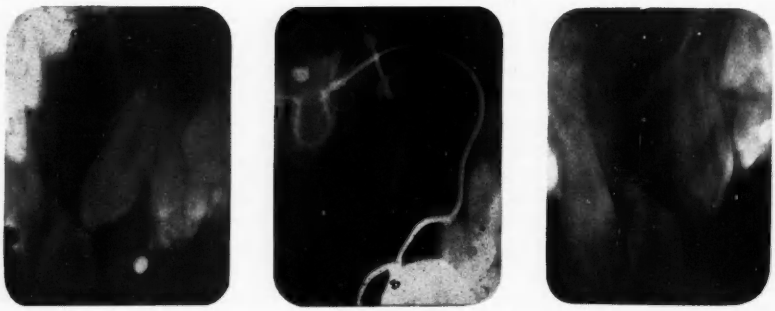

Fig. 4.—Radiographs to show congenital absence of $\underline{2|2}$ and extensive resorption of $\underline{|1}$ due to the impaction into it of $\underline{|3}$. Radiographs also show movement of $\underline{|3}$ into position with the aid of orthodontic treatment. $\underline{|1}$ is vital.

Extraction of the incisor does not always give a pleasing æsthetic result. Where the lateral incisors are absent, and a central incisor has suffered resorption, it is essential to attempt orthodontic treatment to disimpact the canine and move it away from the incisor root (*Fig.* 4). The orthodontic problem is made more difficult where the canine becomes impacted between the roots of the central and lateral incisors, causing resorption of their roots. During operation care must be taken not to expose the apical area of the incisor to infection.

Root resorption may continue after the canine has been moved away from the affected area. It is more common to find repair tissue laid down once the impacted tooth has been moved out of the area. A patient who had suffered resorption of both upper lateral

incisor roots due to the presence of impacted upper canines provides an interesting illustration. On one side the canine remained embedded into the root of the lateral incisor, and on the other side the canine had subsequently moved into alinement in the arch. These teeth were extracted and sections were made of them. Both teeth had normal coronal pulp-tissue and the tooth which had the canine impacted into it showed evidence of active root resorption and the presence of inflammatory tissue. The other tooth showed evidence of repair-tissue laid down after the canine had moved away from it. From this information it may be concluded that a positive attempt at repair is sometimes made in the root of a resorbed tooth, and it is also interesting to notice that the pulp-tissue remained normal in both cases.

7. Congenital Absence of $\underline{2|2}$.—The impaction of a canine in association with the congenital absence of a lateral incisor makes orthodontic treatment a necessity. There is a tendency in these cases for the canine to move mesially into contact with the root of the incisor. It may become displaced into the palate or remain impacted against the incisor. When this impaction occurs against the apical region resorption of the incisor root may take place (*Fig.* 5). There is a great danger under these conditions of the patient losing all the anterior teeth. Although marked root resorption may have occurred in the incisors, it is still important to move the canines into the correct position in the arch. In the event of an incisor being lost at a later date, the canine can be utilized as a bridge abutment.

8. Dentigerous Cyst.—A dentigerous cyst in association with an impacted canine is treated along the conventional lines of opening the cyst and allowing marsupialization to occur with the aid of a suitable pack. The tooth will often erupt as the cyst cavity fills in, but where this movement is not favourable a pin is placed in the tooth to enable controlled orthodontic movement to occur.

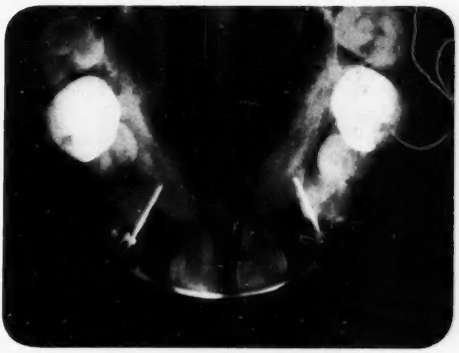

Fig. 5.—Radiographs to show extensive resorption of $\underline{1|1}$ associated with the impaction of $\underline{3|3}$. Patient, aged 12 years, had congenital absence of $\underline{2|2}$. Occlusal radiograph shows apparatus in position with pins inserted from buccal approach. Further radiographs show condition after $\underline{3|3}$ had been moved into position. There had been a continuation of resorption of $\underline{1|1}$. Both teeth are vital.

TREATMENT

Surgical Treatment.—

1. *Treatment by Extraction.*—The real emphasis must be put on early diagnosis and treatment. Where this has been done the extraction

of a temporary upper canine and possibly the first upper premolar will often allow a misplaced canine to erupt into a good position (*Fig.* 6). Where the congenital absence of a lateral incisor occurs, the temporary upper canine and temporary incisor, if present, should be removed at an early date. The incline planes presented by the partial resorption of the roots of these teeth play a major part in the displacement of the permanent canine.

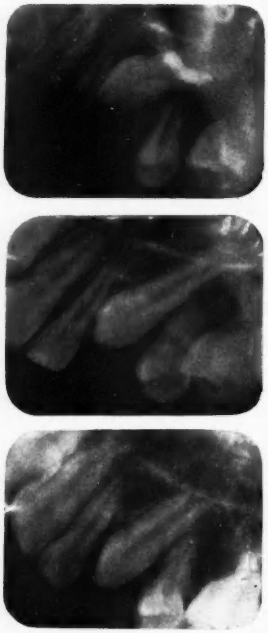

Fig. 6.—A series of radiographs showing the movement of $\underline{|3}$ in patient between 7 and 12 years of age in which $\underline{|3}$ has moved into position after the extraction of $\underline{|C4}$.

Occasionally resorption of the root of a temporary canine becomes arrested and prevents the normal eruption of the permanent canine (*Fig.* 7). Extraction of the temporary tooth together with the removal of any overlying bone will allow the tooth to erupt.

2. *Simple Exposure of the Unerupted Tooth.*—A canine which is lying near the surface and which is not impacted against the adjacent teeth will usually erupt provided that a suitable exit is made for it in the overlying bone and palatal mucosa (*Fig.* 8). The deeper the tooth is lying the more care must be taken to prevent the palatal tissue from growing back and submerging the exposed tooth again.

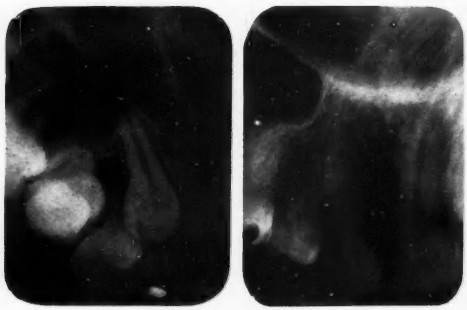

Fig. 7.—Radiographs to show impacted $\underline{3|}$ associated with arrested resorption of $\underline{C|}$. Patient, aged 13. $\underline{3|}$ has moved unaided into position after extraction of $\underline{C|}$.

Fig. 8.—Photograph taken from palatal view of patient with unerupted $\underline{3|}$, one week after section had been removed from overlying palatal mucosa to allow eruption of canine.

Zinc oxide and cotton-wool packs may be placed over the tooth to keep the mucosa back. The pack is changed at intervals of about a week until the tooth has erupted to the surface. During this movement the tooth may be directed into a better position if the pack is pressed down under pressure against the tooth in the appropriate direction. Black gutta-percha packs may be used in the same manner. After the tooth has erupted some difficulty may be experienced in obtaining sufficient purchase with an orthodontic spring

against the tooth. For this reason almost all the teeth which require active movement into position are pinned. This enables a positive force to be applied to the tooth in the simplest manner.

3. *Surgical Exposure and Pinning of the Unerupted Tooth.*—An impacted tooth which is embedded hard against the incisors or

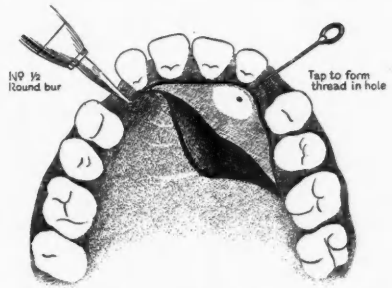

Fig. 9.—Diagram to show pinhole drilled with a No. ½ round bur, the entrance to the hole enlarged with a No. 1 round bur and the hole threaded with a tap of suitable size.

lying in a very poor position usually requires pinning so that controlled movement can be brought about. A tooth which is embedded into the root of an incisor or impacted hard against the root must be disimpacted before it can be brought to the surface. A technique is required which will give good results under adverse conditions without endangering in any way the adjacent teeth. A method which will not mutilate the canine tooth unnecessarily is to be preferred. The operative procedure is usually performed under a general anæsthetic. Visibility is the primary requisite to an efficient pinning technique. The infiltration of the area with a local anæsthetic is recommended to produce some reduction in local hæmorrhage.

a. Palatal Approach.—An incision is made in the palate against the teeth from the second incisor on the opposite side to a point mesial to the first permanent molar on the side of the unerupted canine. A large incision is preferable as it increases visibility and an incision in this position avoids the palatal vessels. The flap is laid back using a periosteal elevator until the whole area overlying the buried tooth is adequately exposed. The neurovascular bundle which passes through the incisive canal is preserved intact to prevent unnecessary hæmorrhage.

Overlying bone is removed with a large No. 10 round bur, working under the influence of a jet or spray of warm saline solution.

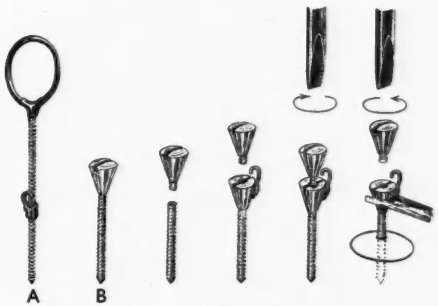

Fig. 10.—Diagram to show: A, Dentine screw with threaded collar and hook attached; B, Stainless-steel type of screw made by Wipla Co. Diagram shows the stages employed to facilitate the final cementation of the pin and removal of pinhead from inaccessible position without disturbing cement union.

The use of a saline spray increases visibility, reduces the traumatic effect of the cutting action of the bur, and reduces the local hæmorrhage. The buried tooth is found and exposed sufficiently to be able to identify its position and axial inclination. More bone is removed with a smaller No. 5 round bur from the distal side to provide an adequate exit for the tooth from the bone.

The most satisfactory position for the pinhole to be made is on the palato-distal aspect of the canine. The hole must be cut into dentine just inside the amelo-dentinal junction. The angle and position of the pinhole are decided largely by the position of the buried tooth, but it is convenient to arrange as far as possible for the pin to emerge through the palate at or near the incision line. The pinhole is cut with a No. ½ round bur into the substance of the dentine. The enamel opening is enlarged slightly with a No. 1 round bur as a necessary precaution against the enamel splitting when the hole is threaded. The thread can be made with a tap synchronized

with the size of the screw pin or if a tap is not available the pin will thread itself to some degree into the dentine. This threaded union between pin and dentine is a necessary

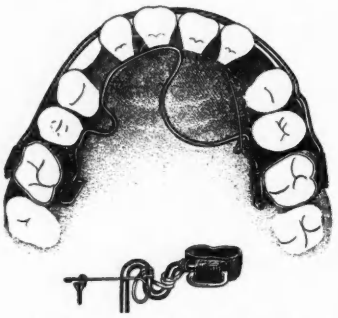

Fig. 11.—Diagram to show pin in position with hook projecting from palate. Apparatus in position and auxiliary spring in 0·3-mm. wire connected to hook.

safeguard against future dislodgement by the stresses and strains to which it will be subjected (*Fig.* 9).

The type of pin available is the dentine screw which can be re-threaded with a more precise thread using a fine watchmaker's die. To this pin is threaded a small collar made in brass or gold. A small hook in 0·3-mm. iridio-platinum wire is soldered to the collar with

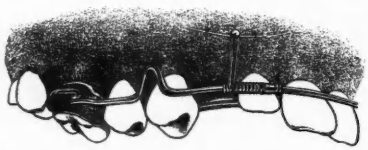

Fig. 13.—Diagram to show incision line, pin in position carrying small acrylic ball, and apparatus with auxiliary spring attached to move tooth impacted on the buccal side of the arch.

18-carat gold solder. In certain positions, particularly where the pin emerges from the buccal side, a small acrylic ball is attached to the dentine screw instead of the collar with a hook attached. This avoids irritation to the surrounding tissue. The other type of pin is made from stainless steel supplied by the Wipla Company. This has a removable threaded component to which a small hook

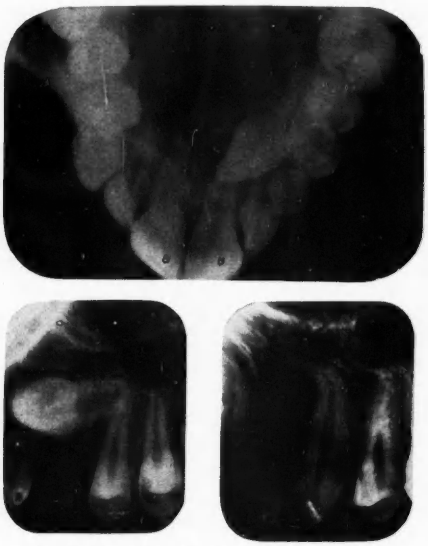

Fig. 12.—Radiographs to show result of treatment to move $\underline{|3}$ into position. The impacted tooth was horizontally placed and on the palatal aspect of $\underline{|2}$. Tooth was pinned from the palatal side and moved into position.

Fig. 14.—Radiographs to show result of treatment to move $\underline{3|}$ into position. Tooth was impacted against buccal aspect of $\underline{2|}$. A pin was inserted from a buccal approach and tooth was moved into position with the aid of a fine wire spring.

of iridio-platinum wire can be soldered with gold solder (*Fig.* 10). No other type of solder union has proved reliable.

The pin is threaded into the pinhole and then removed for cementation. The area is carefully packed with swabs and the pinhole is dried with paper points. Oxyphosphate cement is flowed into the pinhole with a spiral root-filler and the screw pin is threaded back into place. When the cement has set the excess portion of the pin is removed and the flap is sutured back into position leaving the hook projecting from the incision line.

It has proved very much more comfortable for the patient to allow the palate to heal together rather than to keep the space open with packs. As movement of the tooth occurs the excess amount of pin projecting into the palate can be disked away so that the hook is kept on the palate surface. By this means the projection of the pin into the palate is kept to a minimum, avoiding the risk of damage from the bite (*Figs.* 11, 12).

b. Buccal Approach.—An incision is made over the buried tooth into the buccal mucosa of sufficient length to allow adequate exposure of the tooth. The procedure is the same as for the palatal approach, but the pinhole is drilled into the buccal surface of the tooth towards its distal aspect. Where the incision line is high and near the fold of the sulcus, an acrylic ball is attached to the screw pin to avoid unnecessary tissue reaction. The acrylic ball can be screwed up the pin as the tooth emerges so that it remains on the gum surface (*Figs.* 13, 14).

Orthodontic Treatment.—The canine is fairly resistant to movement and usually requires a fixed appliance with adequate anchorage spread round the arch. A large recess is bent into the palatal bow to allow for the rise of the palatal tissue over the buried tooth as it moves. A buccal bow is required to increase the anchorage and to prevent the reciprocal action from the spring from moving the incisors forwards.

There are many forms of spring which prove effective. A canine which requires only a simple tipping action involving a minimum amount of movement in the apical region will respond well to a stronger spring in 0·4-mm. or 0·5-mm. wire, provided that the spring has a wide range of movement. A tooth which is being drawn down through its axis must be moved more gently with a 0·3-mm. wire spring. Since the early stage of the treatment is the most precarious from the point of breakage, the canine is moved through the palate as quickly as possible. Where practical this movement is also made towards the correct position for the tooth in the arch. The pin attachment provides a simple and effective means of applying a controlled spring force to the buried tooth.

A film was then shown to demonstrate the surgical approach to the technique of exposing and pinning a canine tooth from the palatal and from the buccal approach.

Acknowledgements.—My thanks are due to Mr. K. Liddelow, Reader in Prosthetics, King's College Hospital, for his time and great skill in producing the films; to Miss Whiteley, of the Photographic Department, Guy's Hospital, and Mr. Smith, of King's College Hospital, for the photographs; and to Mr. Bailey, of the Chelsea Hospital for Women, for the drawings.

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Retaining Device for Partial Dentures

This device is used in combination with a cast veneer crown on the abutment tooth, and consists of a spring-loaded rod mounted in a housing so that the end of the rod engages a depression in the crown. The device is located on the tooth by means of a cast rest seated in the opposing side of the occlusal surface of the abutment tooth.—Handlers, M. (1957), *J. pros. Dent.*, **7**, 483.

A MOBILE ORTHODONTIC CHAIRSIDE DESK*

By **F. D. ROWE**, L.D.S. Presented by **J. W. SOFTLEY.**

THE operative procedures involved in orthodontic treatment lend themselves well to working in a seated position.

The desk (*Fig.* 1) has been designed to save time and effort and to facilitate carrying out treatment whilst seated.

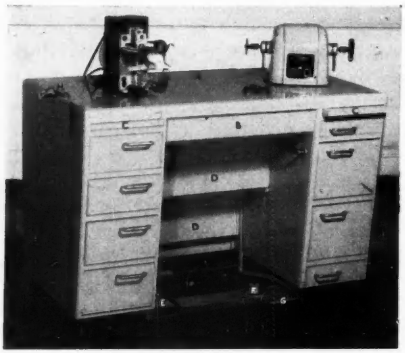

Fig. 1.—A, Flap concealing wire-dispenser chamber, elevated by foot-pedal G; B, Waste drawer; C, Extending leaves; D, Boxes housing spools of chrome alloy strip and wire; E, Foot-pedal for welder; F, Foot control for grinding lathe; G, Foot-pedal for flap covering dispenser chamber; H, Holder for impressions in trays.

The desired characteristics have been achieved by means of the following features:—

1. Mobility.—

a. The desk can easily be moved into whatever position is most convenient for the job in hand. It is mounted on "Shepherd" easy-running, spherical castors.

b. Enables welder, grinding lathe, etc., to be placed close to the patient, so eliminating time-wasting movements and needless expenditure of effort in constructing and fitting appliances.

c. Extending leaves (Formica-covered) can be conveniently placed for writing, as when carrying out diagnosis, filling in records, etc.

d. Since it is designed for operating in a seated position, efficiency in working can be greatly improved if used in conjunction with a mobile stool (e.g., Sterling).

2. Storage.—Almost everything required for treatment (excluding the sterilizer) can be arranged to be within arm's length when seated. At the same time these are concealed from the patient's view until needed. The following items can be accommodated, still leaving further available drawer space for personal requirements:—

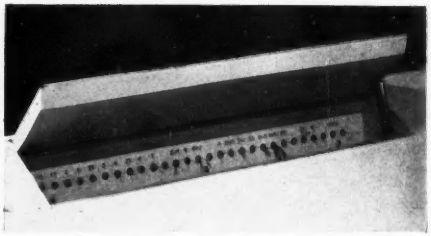

Fig. 2.—Flap covering dispenser chamber, in elevated position.

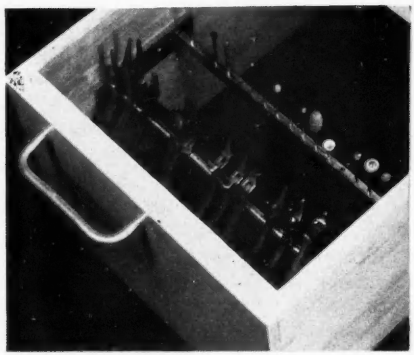

Fig. 3.—Drawer containing plier rail and bur and stone rack.

a. Chrome alloy strip and wire, which are housed in two built-in boxes at the rear of the central knee-hole and enter a chamber immediately under the bench top. When the material is required, a flap covering the chamber (*Fig.* 2) is lifted by pressure on a conveniently placed foot-pedal. The dispenser

* A demonstration given at the meeting of the British Society for the Study of Orthodontics, held on May 13, 1957.

will accommodate 28 varieties of material wound on two sizes of spool, supplied by Temco Ltd. There is a removable panel in the back of the bench which is taken out to give access for loading spools into the dispenser (*see Fig.* 2).

b. Pliers, burs, and stones (*Fig.* 3), mouth instruments, impression trays (*Fig.* 4), mixing

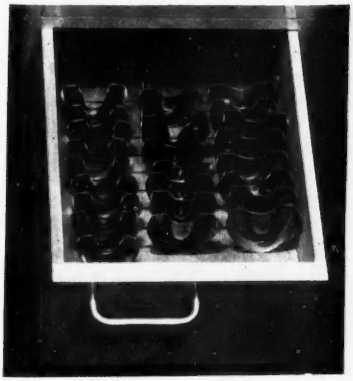

Fig. 4.—Drawer containing impression trays,

bowls, mixers, measured impression material, cements, glass slabs, cotton-wool holder, cotton rolls, waste receiver, wax, X-ray film, X-ray cassettes, plastic containers for appliance components, etc., chrome alloy tubing, oral hygiene leaflets, rubber bands, etc.

c. A wide, centrally placed waste drawer makes it easy to keep the desk-top tidy by providing a receptacle for wire and strip cuttings, powdered acrylic resin from trimming of plates, etc.

d. The wooden stand illustrated in *Fig.* 5 fits in one of the drawers and holds six measures of hydrocolloid impression material and two measures for water. Lids turned out of Perspex fit the powder measures, so avoiding any ill-effects from exposure of the contents to the air. The stand fits in one of the desk drawers, and is removed for refilling the measures. The stock of ready measured powder reduces delays when impressions are required and time is saved by refilling six measures at once.

3. Construction and Finish.—

a. Dimensions: height, 2 ft. 8 in.; width, 3 ft. 9 in.; depth, 2 ft.; knee-hole, 1 ft. 10 in. wide; drawers (8), 10 in. wide.

b. Formica easy-clean top.

c. Sound-deadening material underneath Formica top to reduce noise of placing pliers thereon.

d. Smoothly rounded corners.

e. Light enamel finish.

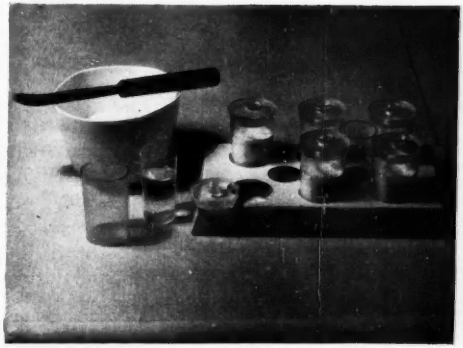

Fig. 5.—Stand for measured hydrocolloid impression material.

Acknowledgements are due to Mr. C. P. Adams, B.D.S., F.D.S., D.Orth., for details of wire-dispenser design, and to Mr. E. W. Rigby, the cabinet-maker who has constructed the desk and to whom I am indebted for many helpful suggestions.

Clinical and Bacteriological Studies of Caries-immune Human Beings

Eighty-nine caries-immune subjects were observed clinically and bacteriologically during a three-year period; these were divided into three groups according to the clinical and anatomical condition of the teeth. Bacteriological examination showed low or negative lactobacillus counts with no symptomatic differences between the three groups. Five of the individuals developed caries during the investigation. In these cases, the repeated occurrence of high lactobacillus counts, especially of the "rough colony type", appears to have indicated impending clinical caries.—WEISENSTEIN, PAUL R., and GREEN, GORDON E. (1957), *J. dent. Res.*, **36**, 690.

HYPNOSIS AND ITS LIMITATIONS IN DENTAL PRACTICE*

By **D. KEIR FISHER**, L.R.C.P., L.D.S., F.F.A. R.C.S.

In dealing with hypnosis and its limitations in dental practice, there are three questions which first require to be answered. These questions are: "What is hypnotism?", What are its dangers?", and "What technique is used?"

WHAT IS HYPNOTISM?

No one seems to know the true nature of hypnosis, but that does not detract from its usefulness. After all, does anyone know the true nature of sleep?

The word, coined by James Braid, was originally neurohypnotism (nervous sleep), but was eventually shortened to hypnotism. We use the word "sleep" in induction, and during the whole session patients have their eyes closed and look asleep. The idea of sleep is always present, possibly because we have no other word in common use which suggests so easily "Rest, Relaxation, Refreshment".

But electro-encephalography shows the pattern in sleep to be quite different from the pattern in hypnosis, which is very similar to the normal conscious pattern and shows a mind and brain alert and responsive. In sleep, a person is unconscious of his surroundings, but in hypnosis he is perfectly aware of what is happening and of his surroundings. It is important to recognize this difference. Even a deeply hypnotized person must hear all the time in order to follow the instructions of the hypnotist. Indeed, one of the recognized methods which patients employ if they dislike a suggestion is to go to sleep, and so to be unable to hear the suggestion. Alternatively, they wake up and refuse to accept it. Both cases show that the patient is in full control and mentally alert.

If it is not sleep—what is it? Certainly not, as Charcot suggested, an indication of hysteria, unless you wish to suggest that 85–90 per cent of the population, the percentage of hypnotizable people, are hysterical. Hypnotic subjects are normal healthy people, and I would suggest that about 85 per cent of the people in your practice are normal healthy people, who could therefore be hypnotized with comparative ease.

The theory of dissociation suggests that the conscious mind is suppressed, and the subconscious, which is suggestible, takes over. This most attractive theory is based on the fallacy that, when the conscious mind is completely suppressed, there is no memory of the events of the trance, and the suggestions of the hypnotist are then received and acted upon. Unfortunately, for the theory, people do remember what happened in the trance and will refuse to carry out suggestions contrary to their wishes or ideas.

Then there is the theory that it is a conditioned reflex, which Salter has revived and explained so convincingly, but even that does not seem to be the whole story.

I wish I could give you a short convincing statement of what hypnosis is, but I fear I must content myself with its effects. This is what we really do know. If a patient will agree to be hypnotized, and we use one of the recognized techniques of eye fixation and monotonous repetitive suggestion, provided the patient can and will concentrate, a trance is developed in which suggestion is much more effective than in the waking state. Suggestion is always effective, but in hypnosis the critical cortical activity is voluntarily inhibited, and we skilfully evoke the emotional reaction. It must be done with the permission and co-operation of the patient, whose trust and confidence must always be secured.

WHAT ARE THE DANGERS OF HYPNOTISM?

We might discuss these under three heads: (1) Danger to the patient; (2) Danger to the hypnotist; (3) Danger to the method.

* From a paper read to the Glasgow Odontological Society on Oct. 15, 1957. The author demonstrated on two patients the induction of hypnosis, cutaneous anæsthesia, and other hypnotic phenomena.

1. Danger to the Patient.—I suppose hundreds of thousands of persons, all over the world, have gone into the hypnotic state, and if there were any outstanding danger to the subject it should have become clear by this time. Since hypnosis is a natural psychological phenomenon there can be no danger from hypnosis itself, but it is equally true that since a person is highly suggestible in the hypnotic state, suggestions can be given which might lead him to harm. If I suggest that a patient can develop anæsthesia of any part of the body at any time, he might abolish, say, the pain of an inflamed appendix until it had ruptured, doing incalculable harm, but obviously that is not the fault of hypnosis, but the fault of the suggestion.

It has been suggested that the induction of hypnosis may precipitate a psychotic episode. This seems a reasonable possibility, but we have no evidence that it has occurred. I would say that if one has any doubt of a patient's mental stability one should refuse hypnosis.

2. Danger to the Hypnotist.—Since there is always the danger of lawsuits, it seems wise always to have a third person present. Some hypnotists insist on a signed statement agreeing to hypnosis and, in dealing with children, one should have the permission of the parent or guardian.

3. Danger to the Method.—If we admit that the use of hypnosis is valuable to promote the welfare of the patient, then we should protect the method from adverse criticism. The hypnotist should never promise more than he can reasonably expect to achieve. Do not use the method on the theory that if it does no good it will do no harm. We must have a definite reason for its use, and a specific aim in view in its application.

WHAT IS THE TECHNIQUE OF HYPNOTISM?

There are two techniques: (1) The Authoritative; and (2) The Passive.

1. In the *Authoritative Method* the hypnotist assumes the role of magician, as in stage shows. He orders; he commands; he gets his results by the imposition of his personality on the subject. It is rapid, it is spectacular, it is (in my view) quite wrong, and sets up antagonisms in the patient, and very often does more harm than good. It may satisfy the ego of the hypnotist but it never really helps the patient.

2. The *Passive Method* is slow, unspectacular, and educative, and the patient is trained to take control. It is the method in use in medicine, in which we adopt the role of teacher, training the patient to control his own reactions. He is taught to do everything himself so that he becomes more self-confident and self-reliant. It is more difficult, more time-consuming, but the results are more satisfactory. As one patient said to me, "You have taught me something that will help me all my life".

THE APPLICATION OF HYPNOTISM TO DENTISTRY

My own experience has been as a hypnotherapist and anæsthetist, not as a hypnodontist.

I have not used hypnosis to replace general or block anæsthesia for oral surgery, but I have used it as a preparation for induction of general anæsthesia, and for conditioning patients for local anæsthesia and for fillings, the patients being taught how to keep control of their sensations.

Hypnodontists report success in oral surgery in controlling salivation, stopping hæmorrhage, and encouraging healing—in fact in all departments of dental operative work. I am sure it can be used in all spheres if the dentist is keen enough to learn the technique and to devote the necessary time to training. But, of course, barbiturates are handy and effective, xylocaine is easy and reliable, and nitrous oxide and trilene have established reputations.

They always work, so should you change? In 1934 Crampton said, "Personality is nontoxic and does not throw any strain on the heart, liver, or kidneys, nor does it depress respiration".

I very much doubt if every patient should receive hypnotic treatment, just as I doubt if every patient should receive analgesic treatment. But we should know how it works. I am sure that every practice would benefit and

the status of dentistry as a whole would be improved, if every dentist used the hypnotic approach and the power of suggestion.

If you are to be successful in hypnodontia you must first believe in dentistry not merely as a means of making a living. You must believe in your treatment and anæsthetics, and be assured that any patient can be comfortable while having treatment in the dental chair, and you must train your attendant and your staff to think positively, too.

How often do you hear "This won't hurt", or worse still "This will hurt a little"; "This won't be uncomfortable"; "You're not going to feel any pain, so don't worry"?

Aren't these your usual speech patterns? Haven't you developed an apologetic approach, whilst in hypnotism we approach everything from the positive attitude. Instead of saying "The glass is half empty," we say, "The glass is half full".

All negatives must be eliminated from your thought and conversation. Words like pain, hurt, discomfort, and uncomfortable must not be used. You cannot tell an ill patient he is well, but you can say—you *are* becoming well, rather than you *will* become well. Always talk in the present rather than the future, unless your future is definite, and then you speak in the present future, e.g., "Next Thursday you are able to open your mouth".

Say rather: "You are poised, you are self-confident, you are courageous, you are friendly", not "You are not afraid, you are not self-conscious, you are not shy".

You must train yourself. In fact, you must live with it all day.

To every patient you give suggestions. Make them good ones.

See that the chair is carefully adjusted. Suggest that some patients sleep while you work and keep making positive suggestions. In fact if you mix equal parts of xylocaine and suggestions, you will be surprised at the results. But, unless you are convinced that full hypnotism is your forte, be content with that.

The limitations of hypnotism concern the type of operation, the type of patient, and the type of dentist.

1. *The Operation.*—If the operation requires full anæsthesia, hypnosis is not a challenge to modern anæsthetic methods. But, if the patient has been conditioned, your block anæsthesia will be less trying to him and your general anæsthesia may be more easily induced. On the other hand, where local or general anæsthetics would involve considerable risk, the use of hypnotic anæsthesia should be considered. However, it may take some time to train the patient, and the number who can achieve full anæsthesia is comparatively small.

2. *The Patient.*—He must believe in hypnosis and in the hypnotist. I can give chemical anæsthesia to a patient who doesn't like me or believe in me or my methods, but I cannot hypnotize anyone against his will. So the patient must co-operate. In fact the patient must really do the job himself.

3. *The Operator.*—Have you the personality for this thing? The average dentist would require to retrain himself, and his staff, before he could make any attempt at hypnodontia.

Remember that it is easier to control the patient than to control the hypnotist. Only do hypnotism if you are sure you can talk and think positively, and make every suggestion have a constructive purpose.

Hypnotism is an art which can be learned, as violin playing can be learned, but whose principles likewise should be thoroughly mastered before being inflicted on the public.

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GENERAL DENTAL COUNCIL

THE Council will meet in public session for general business at noon on Tuesday, 13 May, 1958.

The Disciplinary Committee of the Council will meet in public session at 10.30 a.m. on Wednesday, 14 May, 1958.

FUNDAMENTALS OF COLLAGEN*

By Professor **W. T. ASTBURY**, F.R.S.
Department of Biomolecular Structure, University of Leeds

By "fundamentals" of collagen, to which I understand you would prefer I devoted this talk, I mean the state of things at and near the molecular level, chiefly as revealed by electron microscopy and X-ray diffraction analysis. The resolving power of the electron microscope to-day is a hundred times better than that of the optical microscope and brings us therefore into the region of Ångstrom units (1 Å=10^{-8} cm.), where previously only X-rays penetrated. Atomic details require X-ray diffraction still, but the two techniques have now begun to overlap in a borderland of peculiar importance.

The classic picture of collagen as seen in the electron microscope is that of rat-tail tendon (*Fig.* 1, for example). It shows the famous transverse bands which are spaced at approximately 640 Å and which are resolvable after appropriate staining into half a dozen or more sub-bands, and it also shows† how, when the fibrils are swollen by suitable reagents, they tend to split longitudinally into finer and finer sub-fibrils. (This progressive splitting phenomenon, by the way, does not hold for all types of collagen fibrils: those in the dermis, for instance, though otherwise looking very similar, do not seem to show it.) Eventually we must come in this way to the constituent chain-molecules, but to "see" them the classic picture is of the kind provided by *Fig.* 2, an X-ray fibre diagram, which is not, of course, a micrograph in the ordinary sense but a pattern of "spots" formed by the diffracted beams from which we try to reconstruct what diffracted them—in this case the arrangement of polypeptide chains in the collagen structure.

The large-angle X-ray diagram is the most "fundamental" and persistent view we have of collagen at the moment, because it is an expression of the configurational plan of the molecule and this turns out to be common to numerous formations that were once thought to be little related, or not related at all, to orthodox collagen. X-ray studies have shown that all or practically all the fibrous proteins fall into one or other of only two configurational

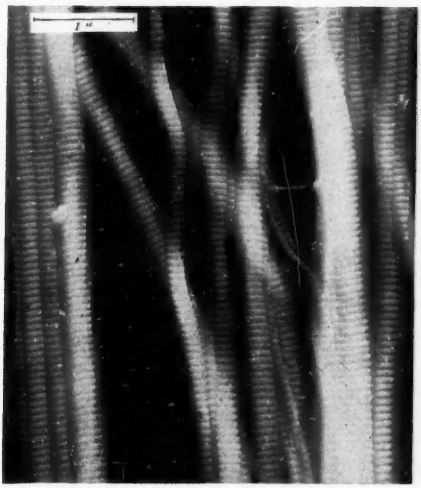

Fig. 1.—Electron micrograph of collagen fibrils in rat-tail tendon, "cleaned up" a little by treatment with trypsin. The particles scattered about the field for comparison are of colloidal gold (about 160 Å diameter).

families: the long-range-elastic keratin-myosin-epidermin-fibrinogen (k-m-e-f) group, and the effectively inelastic collagen group. The latter is now known to include also reticulin, vitrosin, ichthyocol, ichthylepidin, elastoidin, cornein, spongein, "ovokeratin", "byssokeratin", earthworm cuticle, and the threads ejected by the sea-cucumber, for example. Indeed, though various chemical criteria have been suggested, notably the one requiring a high hydroxyproline content, really what is meant by collagen nowadays is anything—never mind its other appearances—that gives an X-ray diffraction pattern of the type of *Fig.* 2. This pattern, which gelatin gives too, clearly stands

* A lecture given at the meeting of the British Society of Periodontology, held on May 4, 1957.

† Only a small selection of the photographs and slides used to illustrate the actual lecture is reproduced here.

for one of the great master plans of molecular biology.

It is some twenty years since I first argued that the polypeptide chains in the collagen structure, though apparently inextensible, must be constricted or crumpled as compared with those in silk fibroin and β-keratin; that,

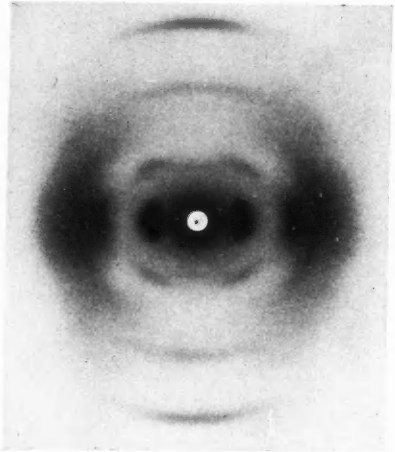

Fig. 2.—The large-angle X-ray diffraction diagram given by rat-tail tendon. (The white spot marks the centre of the diagram, and the fibre axis is parallel to the long edge of the page. Cu Kα rays.)

in fact, the mean amino-acid residue-length in the direction of the fibre axis (as inferred from the spacing of the characteristic meridional arc) must be only 2·86 Å instead of the expected 3·5 Å or so in chains that are nearly fully extended; but an acceptable more detailed interpretation was not achieved till quite recently—as the result of a relatively sudden coming-together of ideas and findings from a number of workers. Pauling and Corey set it off with their inspiring and now well-known derivation of various helical configurations of polypeptide chains, and soon afterwards the helical concept was put into an elegant X-ray diffraction form, so to speak, by Cochran, Crick, and Vand (1952). Then, after several less convincing attempts by different people to apply it to collagen, came a structure proposed by Ramachandran and Kartha (1954, 1955, 1956). This was incorrect as it first stood, but it was at last along the right lines, and the required improvement was shortly forthcoming in the light of X-ray analyses of poly-L-proline (Cowan, McGavin, and North, 1955) and of the crystallographic modification of polyglycine now called polyglycine II (Crick and Rich, 1955).

You would not wish me here to go into all the "pros and cons"—the long invaluable investigations of Bear, for instance, leading finally to a firm "pro", and the stimulating "con" arguments of Huggins—but I should like to describe at least the gist of the solution, which, I believe, is now pretty generally accepted as sound in outline, however the finer points may turn out. As just hinted, the ultimate basis is the structure found by X-ray diffraction to be common to poly-L-proline and polyglycine II, which consists of a trigonal array of helical chains in each of which there are three residues per turn and the length per residue is about 3·1 Å. The chains in polyglycine II are cross-linked by a six-fold system of CO...NH hydrogen bonds which are of course not possible with poly-L-proline because proline is an imino acid; nevertheless the polypeptide backbone configuration is the same in these two chemical extremes between which collagen lies, with one-third of its residues glycine and at least another quarter proline or hydroxyproline, and from this one might perhaps, therefore, guess at once that collagen structure would be a closely related compromise, some simple adaptation of the polyglycine–polyproline structure.

And so it transpires. The collagen structural unit corresponds to a *triad of chains* in the polyglycine-polyproline structure, but whereas in the latter the pattern repeats every three residues (about 9·3 Å), the repetition in collagen occurs after a length equal to that of ten residues (28·6 Å). How this comes about may be followed with the aid of the skeleton model photographed in *Fig.* 3. The unit triad of polypeptide chains is represented by three lengths of rubber pressure-tubing on which are strung short metal tubes plus side-pieces serving for the flat amide groups (–CO–NH–) of successive amino-acid residues, and the cross-linking hydrogen bonds, –CO....HN–, are formed by thin wooden rods bored out to

receive and thereby hold together the side-pieces of opposing CO and NH groups. *Fig.* 3 A corresponds to the situation in polyglycine II and poly-L-proline: successive residues along each length of rubber tubing are rotated through 120° so as to represent a left-handed helix with three residues per turn, and the screw-axes of the three polypeptide chains of the triad are straight. The model is made ten residues long, which means that the last residue is rotated through 120° to the left with respect to the first, in order to illustrate what is required now to transform it into the collagen framework. We have simply to twist one end of the triad through 120° to the right so as to cancel out this extra 120° per ten residues, so that we are left with a compound helix which *repeats* at that length (*Fig.* 3 B). In the actual molecule this superposing a right-handed twist on the three left-handed helices results of course in a shortening besides, the length per residues along the main axis being reduced to 2·86 Å. The Randall school have shown that it is possible, though, to stretch the system again elastically by something like 10 per cent, but this is not easy, and it still remains that the molecules themselves in collagenous tissues have normally hardly any "give" at all.

The model constructed as in *Fig.* 3 illustrates only the indispensable outlines of the collagen unit—the backbone configurations of the polypeptide chains without reference to the kinds of residues involved. This latter is a business many or most of the details of which have yet to be elucidated, even were this the place to go into them. There are one or two points, however, that now seem rather clear and that I might touch upon, the most important being that there are *two* geometrical possibilities or manifestations, so to say, of the structure that have to be reckoned with when it comes to fitting in all the known side-chains, especially those of proline and hydroxyproline. In one of these arrangements—called collagen II and generally favoured at the moment—the hydroxyprolines stick out in a way that debars them from forming *intra*-triad hydrogen bonds; they can only build *inter*-triad bridges, probably through their hydroxyl groups after the manner proposed by Gustavson. Gustavson has drawn attention to a striking though not invariable tendency amongst native collagen structures to have higher thermal shrinkage temperatures the higher their hydroxyproline contents, which suggests that a principal difference between native collagen and the

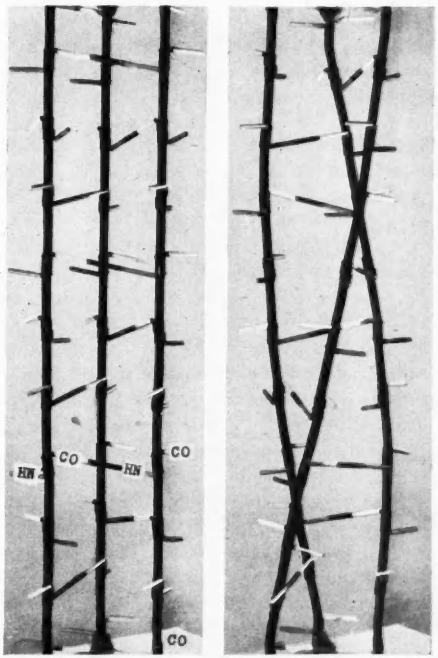

Fig. 3.—Skeleton model illustrating (A) a triad of polypeptide chains from the structure of polyglycine II and poly-L-proline, and (B) the geometrical operation that transforms such a triad into a unit of the collagen structure.

gelatin that can be produced from it (without loss of hydroxyproline and without any particular change in the large-angle X-ray diagram, be it noted) derives from this characteristic of the collagen II arrangement of having its hydroxyprolines available for external linkages only, that is between whole triads as opposed to between their polypeptide-chain components. In any case the latter must be held together at least by hydrogen bonds between glycine residues (*Fig.* 3), which almost certainly occupy every third place along each

chain wherever else the other kinds of residues are located. A frequent sequence found in recent chemical analytical studies which also favours the collagen II alternative is (-glycine-proline-hydroxyproline-), but there are not enough imino residues for all three chains to be exclusively like that, which in a sense is all to the good, for the structure pictured in *Fig.* 3 stands for a fundamental theme on which nature has obviously played many variations, presumably sometimes modifying chains or parts of chains, sometimes triads of chains, sometimes combinations of triads, and so on up to visible fibrils, fibres, and tissues. There is a tremendous amount of work still to be done.

A stage of organization close above the basic level we have just been discussing shows itself in the higher axial period of about 640 Å, the interpretation of which has been much advanced lately by the demonstration, notably at the hands of Gross, that it is not the only one possible. Axial periods of about one-third this "natural" period had been observed in embryonic tissues and in tissue culture by Porter and by Randall and co-workers but the illuminating new discovery is that collagen can be reconstituted from solution in two other structural forms, the so-called "fibrous long spacing" and "segment long spacing"; both on the average about 2400 Å; and, moreover, that all three forms are interconvertible by appropriate re-dissolving and re-precipitation. The same building units are put together in three different ways.

These units have been named *tropocollagen* and identified with the stiff rod-like particles, of size about 2900 Å by 14 Å and weight about 340,000, inferred by Boedtker and Doty (1955) from physico-chemical studies of ichthyocol solutions. Altogether, the view now is that they must be the same thing as the unit polypeptide triads of the X-ray crystallographer, that their probable length in situ lies somewhere in the range 2600 Å–2800 Å, and that the various observed high periods and types of transverse striations (including no striations at all in the fibrils of the worm's cuticle and in some of the laboratory preparations) represent "beats" as it were, resulting from fitting the rods side by side according to different schemes (or lack of scheme), which may be "parallel" or "anti-parallel", with sometimes systematic axial overlapping ("staggering") besides, as seems specially the case in the 640 Å natural period.

The high axial periods and transverse bands of the fibres of the collagen group hold, of course, a peculiar interest for dental research because of the great problem of apatite formation, and structural relationships are in fact beginning to come to light which look very promising. The periodic repetition of pattern —and much fine detail has been recognized in the electron microscope that finds, too, its counterpart in the small-angle X-ray diagrams of which Bear has made such outstanding studies—is an expression of the order in which the constituent amino-acid residues follow one another along the polypeptide chains, and if this sequence incorporates, as is a fair assumption, combinations responsible for, or at least controlling, the manufacture and deposition of hydroxyapatite and its relevant modifications, then it is to be expected that a preferential association, some sort of distinctive juxtaposition, must reveal itself at some stage or other. The technique of resolving, as electron microscopists have done, the inner components of the bands by "staining" with phosphotungstic acid is the most familiar demonstration of the possibilities, and there are also stimulating observations in the same regard by the method of silver staining. Schwarz (1957), for example, has concluded that the affinity for silver is associated with the main dark band of the cross-striation (Bear's less ordered region), and that it is developed progressively through a broad "spectrum" of connective tissue fibres, deposition taking place in random fashion on the *surface* of embryonic sclera for instance, on the *surface*, too, of reticulin fibrils but in topographical relation to the dark band, and finally *inside* the dark band with collagen fibrils. He states that all embryonic and newly forming connective tissues take this path in their differentiation, though they do not all reach the final stage of intra-fibrillar staining, stopping short each at its own particular function—going

beyond, indeed, leading to impairment of function, as when the cornea develops opacity.

What appear to be analogous observations in relation to hydroxyapatite deposition are the recent findings of Fitton Jackson (1957) with osteogenic tissue in embryonic fowl. She describes how at an early stage of calcification dense particles, less than 100 Å in size, become localized in a ring in the major region of indentation, that is the main *interband* (Bear's more ordered region), of the collagen fibrils; more precisely, they are seen almost exclusively between the so-called *d* and *ab* bands. Electron diffraction diagrams indicate at the same time that they are hydroxyapatite crystallites, not preferentially oriented though, it seems, with respect to the fibril axis, as has been shown to be the case in adult bone by Engström and his school. Using X-ray diffraction they have found elongated crystallites, approximately 220 Å by 73 Å in size, lying parallel to the collagen fibre axis, and the very intriguing thing about this, I need hardly point out, is the close equivalence in length with one-third the fundamental 640 Å period.

I have spread this talk, rather thinly I am afraid, over questions of collagen structure at their deepest and widest—and I must emphasize again that "collagen" these days implies a master plan covering a multitude of tissues—but I conceive it a debt of honour at this meeting of the British Society of Periodontology not to depart without at least a token contribution to your more immediate interests. I propose, therefore, to conclude by showing, and passing a few comments on, some electron micrographs and X-ray diffraction photographs taken specially for the occasion, of specimens kindly provided by the Leeds Dental School.*

The appearance in the electron microscope of untreated pulp (from a human incisor) is illustrated in *Fig.* 4, and on comparison with *Fig.* 1, which is of rat-tail tendon at the same magnification as *Fig.* 4 B, one notices at once how very much thinner the collagen fibrils are in pulp—something like ten times thinner than in tendon, recalling reticulin in fact. They are scarcely 300 Å thick, and they are beautifully uniform. The axial periodicity is unusual, too: it manifests itself mostly as a succession of half-periods (approximately 640/2 Å), and these in turn are subdivided into three.

Collagen can only just be detected in X-ray diagrams of untreated dentine because of the preponderating effect of the hydroxyapatite, aggravated by the fact that the strongest ring of the latter almost coincides with the characteristic collagen reflection at 2·86 Å; but after treatment with acid, say 1 per cent HNO_3 for two days, the apatite reflections disappear and give place to a perfectly clear disoriented collagen diagram. There is a similar difficulty with electron photomicrographs of dentine, but *Fig.* 5 shows how the collagen fibrils are uncovered by two days' treatment with N/5 HCl, for example.

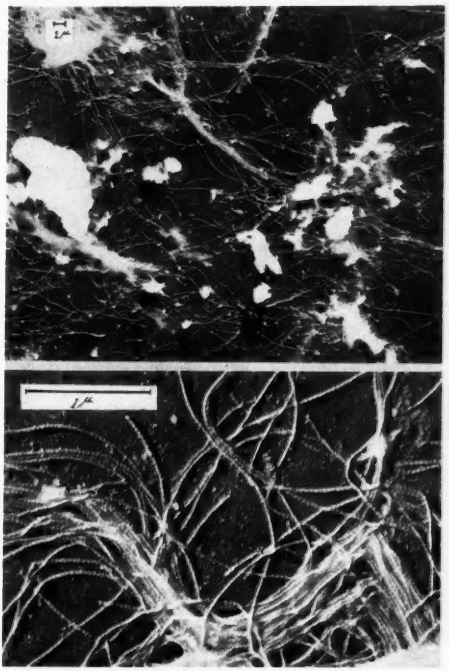

Fig. 4.—Electron micrographs of untreated pulp from human incisor: A, general view at low magnification; B, a field of collagen fibrils at higher magnification. (Specimens shadowed with platinum.)

* Only a small selection of the photographs and slides used to illustrate the actual lecture is reproduced here.

And for my last picture, the obvious gesture is to put up what might be called an eponymous illustration—I mean of the human periodontal membrane itself (*Fig.* 6). Beyond teasing the tissue apart in order to arrive at a preparation small enough for the electron microscope, the specimen was untreated, and you will see that again it consists mostly of collagen fibrils, and that again, as in pulp, they are as remarkably fine and uniform as the histological heart could wish for.

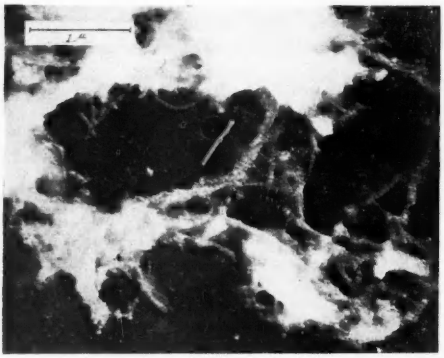

Fig. 5.—Electron micrograph of dentine from human molar after two days' treatment with N/5 HCl, followed by washing.

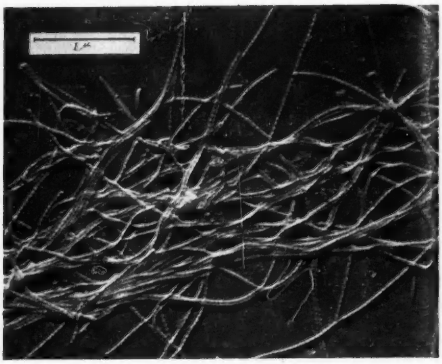

Fig. 6.—Electron micrograph of untreated human periodontal membrane.

One final word—to the effect that these special dental illustrations are not intended to be anything more than simple catalysts. As I insisted earlier on in this talk, there is a tremendous amount of further work waiting to be done, which still beckons us "ever on and upward", and is enough to keep us all going for ages.

I should like to thank Professor Talmage Read and his staff for the specimens, and my colleagues, Mr. Millard and Dr. Beighton, for taking the electron micrographs and X-ray photographs. Mr. Millard also made all the photographic enlargements.

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RICH, A., and CRICK, F. H. C. (1955), "The Structure of Collagen", *Ibid.*, **176**, 915.

SCHWARZ, W. (1957), "Morphology and Differentiation of the Connective Tissue Fibres", *Connective Tissue Symposium of C.I.O.M.S.* (*see above*).

BOOK REVIEWS

ORAL MEDICINE. By LESTER W. BURKET, A.B., D.D.S., M.D., Sc.D. Third Edition. $10\frac{1}{4} \times 7\frac{1}{4}$ in. Pp. 558, with 391 illustrations including 40 in colour. 1957. London: Pitman. 100s.

THE new edition of this work serves to bring up to date a book which in its previous two editions has become firmly established as an important monument in dental literature. The general structure remains relatively unchanged while alterations and replacement of some of the illustrations, references, and text have been pursued energetically where necessitated by recent advances.

The opening chapters devoted to history-taking and diagnosis are unlikely to be accepted enthusiastically in this country, where there is generally a reluctance to employ the stereotyped questionnaires advocated by the author. Throughout the book it is noticeable that stress is laid upon diagnosis and treatment whereas the histopathology of lesions, even when as distinctive as Paget's disease, are completely neglected. Some sections of the book therefore create an impression of incompleteness although in justification it can be pointed out that the full title of this book is *Oral Medicine—Diagnosis and Treatment*. The early chapters dealing with gingivostomatitis should not be compared with the standard achieved by the contemporary texts available on periodontology, but the section on ulcero-necrotic gingivostomatitis is outstanding for its grasp of the fundamental requirements in the proper management of this troublesome condition. Of the succeeding chapters those on the dermatoses, the tongue, and the disorders of the blood and blood-forming tissues should be singled out for special mention. This is essentially a practical book in which the author has the happy knack of setting out to answer many of the questions which arise as practical problems and for which the answers are not readily available from other texts. For example, reference may be made to the section on dental surgery in diabetic patients. It is also characteristic of the author's approach that a chapter is included on the occupational diseases to which the dentist is exposed. Special mention must be made of the chapter on Oral Cancer contributed by Dr. S. Gordon Castigliano. This should be read by every dental student and by every dentist and then re-read at intervals throughout his professional life.

The section devoted to laboratory procedures is no doubt of value to remind the clinician of the nature and true worth of the investigations for which he may call, but is insufficient in itself to enable these tests to be carried out with the high degree of accuracy expected from the modern clinical laboratory. The colour illustrations are all collected into an atlas at the back of the book and are unchanged from the previous edition. They reach a high overall standard and are good of their kind.

The few criticisms that can be made of this book do not detract in any significant way from its acknowledged value. The earlier editions have been a source of great help to many of us in the past and this new edition is sure to maintain their high standard.

J. A. P.

IMPLANT DENTURES. By AARON GERSHKOFF, B.S., D.D.S., Past President, American Academy of Implant Dentures; and NORMAN I. GOLDBERG, D.D.S., Past President, American Academy of Implant Dentures, with a foreword by IRVING R. HARDY, D.M.D., Professor of Graduate and Post Graduate Prosthetics, Tufts College Dental School. $9 \times 5\frac{3}{4}$ in. Pp. 256 + xvi, with 327 illustrations. 1957. London: Pitman Medical Publishing Co. Ltd. 70s.

THIS book is a straightforward account by two pioneers of dental metallic implants and their early attempts, successful and otherwise, to insert subperiosteal implants to carry dentures. It includes a detailed step-by-step description of their present technique. This description occupies the major part of the book, and is divided into sections giving the complete sequence for the edentulous mandible, edentulous maxilla, and the partially edentulous case.

The presentation is excellent save for a little loose syntax, a little careless proof-reading,

and the use of the horrible word "implant-odontics". The language is clear and concise, except for a tendency to repetition in the sections on procedures. Illustrations are many and apt, and the description throughout has the unmistakable stamp of the man who writes from his own experience.

It is to be noted that although a precise technique is laid down in order to secure the maximum hope of success, the main stress is on the fundamental principle that the weight taken by the implant must be transmitted to permanent structures and not alveolar bone: a mistake made in early designs. The next most important point is accurate fit to the bone throughout; and thirdly, perfection of mechanical technique in constructing the implant itself and the metal frame of the superstructure. For the rest, experience and skill in intra-oral surgery are sufficient.

The authors attempt, with some success, to meet their theoretical opponents on their own ground; a chapter contributed by Leon Herschfus is inserted describing, with microphotographs, extensive animal experiments, as a result of which he is able to state (p. 188): "Tissue around the abutments was firmly attached . . . the gingival crevice was about a third the length of the abutments . . . (p. 191) evidence of an active inflammatory process was lacking. Epithelial downgrowth along the implant or atypical epithelial hyperplasia was not observed." This statement alludes to conditions obtained after periods up to 16 months after implantation and would seem to dispose of the objection that the ultimate state of affairs must be unlimited downgrowth of epithelium with final exfoliation of the implant.

A useful chapter is devoted to contra-indications, absolute and relative, and at the end of the book the authors give an account of a number of typical cases, failures as well as successes. The authors record a very high percentage of successes lasting 5 or more years with the technique they now use.

This will be a most valuable book in the right hands, and the authors deserve high praise for their sustained and concentrated efforts over a period of many years to evolve a solution of the wearing problem of the patient who cannot tolerate conventional dentures.

N. J. A.

THE DESIGN AND CONSTRUCTION OF REMOVABLE ORTHODONTIC APPLIANCES. By C. PHILIP ADAMS, B.D.S., F.D.S., D.Orth. Second edition. $9\frac{3}{4} \times 7\frac{1}{4}$ in. Pp. 120, with 173 illustrations. 1956. Bristol: John Wright & Sons Ltd. Cloth bound 21s.

THAT this book should reach its second edition only two years after first appearing in print is in itself a sufficient recommendation.

The outline and basic form of the book remain the same but new sections dealing with expansion and welding have been added and these retain the original high standard. There is also an appendix, discussing the relationship between British and metric wire dimensions, which will be found to be useful.

It has sometimes been said that removable appliances have a limited place in orthodontics because of their lack of efficiency. This is very often due to faults of design and construction and not to the inherent characteristics of the appliances. Mr. Adams is at pains to point out the limitations of removable appliances—particularly in relation to bodily movement and rotation of teeth. But anybody who carries out the techniques suggested in this book will no longer have any doubts as to the efficiency of removable appliances.

J. S. R.

Electrolytic Action in the Mouth and its Relationship to Pain

An investigation into the cause of pain as a result of electrolytic activity in the mouth is described in this paper. Various experiments with amalgam and gold electrodes immersed in saliva, blood, and serum were devised.

With serum as electrolyte, E.M.F.'s up to 639 millivolts were recorded. The resistance of dentine may vary between 10,000 ohms and 1 megohm giving a current range of 0·5 to 50 microamperes. It is suggested that the higher current could cause brief sharp pain. Slight damage to the pulp might give rise to a dull pain of persistent type.—MUMFORD, J. M. (1957), *J. dent. Res.*, **36**, 632.